Guide to Traffic Impact Assessment Practice Note:

Pavement Impact Assessment

December 2018

Queensland Government

Document control

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1. Introduction

1.1 Purpose

The Guide to Traffic Impact Assessment (GTIA) (Chapter 13) requires proponents of development in Queensland to ensure that increased traffic generated by development does not worsen the pavement condition of state-controlled roads (SCR). Impacts on the pavement condition of state-controlled roads is determined by undertaking a Pavement Impact Assessment (PIA).

The GTIA introduced a new process for preparing a PIA, with two major changes from the process under the previous Guidelines for Assessment of Road Impacts of Development (GARID), including:

- a new assessment methodology referred to as the ‘marginal cost methodology’ which replaced a range of other methodologies, including the Fitzroy methodology
- the concept of Standard Axle Repetitions (SAR) which replaced Equivalent Standard Axles (ESA).

This Practice Note supplements Chapter 13 of the GTIA by providing further guidance for industry on how to prepare a PIA using the new marginal cost methodology and the concept of SARs. This Practice Note should be read in conjunction Chapter 13 of the GTIA.

1.2 Reference material

Further guidance on the determination of marginal costs can be obtained from the following specialist reports:

- Deploy and Refine the Road Wear Modelling Methodologies: FAMLIT Final Report (AP-R501-15)
- Freight Axle Mass Limits Investigation Tool (FAMLIT) User Guide (AP-R502-15)
- A27 Harmonisation of Pavement Impact Assessment: Updates and Extended Marginal Cost Values (2018, TMR/ARRB NACOE Project Report).

2. Key concepts

2.1 Marginal cost methodology for sealed roads

2.1.1 Overview

The performance of sealed road pavement is modelled based on the amount of heavy vehicle traffic, measured in Standard Axle Repetitions (SAR), and other factors such as pavement strength and climate. Over a 50-year life cycle, typical pavement costings include maintenance, rehabilitation and reconstruction. As such, it is possible to estimate a ‘marginal cost’ per SAR for the life of the pavement (i.e. typical costs over 50 years divided by a pre-determined SAR loading).

TMR has calculated the marginal cost (cents per SAR-km) for all sealed pavements on the SCR network, by 100 metre segment.

2.1.2 ESA vs. SAR

Under GARID, ESA is defined as:

> *"A measure defining the cumulative damaging effect to the pavement of the design traffic. It is expressed in terms of the equivalent number of 80kN axles passing over the pavement up to the design horizon."*

The formula to calculate ESAs is outlined in Figure 1.

$$ESA_{ij} = (L_{ij}/SL_i)^4$$

axle load (L_{ij})

standard load (SL_i)

Figure 1: ESA formula

(*Source: TMR Technical Note 167: A new Approach to Asphalt Pavement Design, 2017*)

Under GTIA, SAR is defined as:

> *"A measure defining the cumulative damaging effect to the pavement of the actual traffic, it is expressed in terms of the equivalent number of 80kN axles passing over the pavement up to the design horizon."*

The formula to calculate SAR is outlined in Figure 2.

$$SARm_{ij} = \left(\frac{L_{ij}}{SL_i}\right)^m$$

where

$SARm_{ij}$	=	number of Standard Axle Repetitions (or passages of the Standard Axle) which causes the same amount of damage as a single passage of axle group type i with load L_{ij}, where the load damage exponent is m
SL_i	=	Standard Load for axle group type i (from Table 2.3 – Base Load per SAR4), which causes the same damage as a Standard Axle
L_{ij}	=	j^{th} load magnitude on the axle group type i
m	=	load damage exponent for the damage type (from Table 2.1)

Figure 2: SAR formula

(*Source: Adapted from Austroads Guide to Pavement Technology Part 2: Pavement Structure Design, 2012*)

The methodology to calculate ESAs and SARs is generally the same. The only difference is that SAR accounts for the exponential load damage by different pavement type such as for granular pavement (SAR4), asphalt (SAR5) and cement stabilised pavements (SAR12).

The SAR terminology was adopted in the GTIA to align with more recent Austroads publications identifying the marginal cost of pavement impact based on 'cents per SAR-km'. These employ network-level pavement performance models and details of their application are provided in the specialist reports listed in section 1.2 of this Practice Note.

2.1.3 Pavement type vs. load damage exponent

The marginal cost methodology considers the following three (3) pavement types:

- granular pavement (GN)
- asphaltic concrete pavement (AC)
- cement stabilised pavement (CS).

Table 1 provides a summary of the 'load damage exponent' and 'damage unit' for each pavement type.

Table 1: Pavement types and load damage exponent

Pavement type		TMR pavement type	Type of damage	Load damage exponent	Damage unit
Granular pavement with thin bituminous surfacing	Granular pavement (GN)	Sprayed seal over flexible pavement, including cement modified and lime stabilised layer types C4 and C5	Overall pavement damage	4	ESA / SAR4
Pavement containing one or more bounded layers	Asphaltic concrete pavement (AC)	Sprayed seal or asphalt over flexible pavement with bitumen stabilised pavement	Fatigue of asphalt	5	SAR5
		Asphalt over flexible pavement, including cement modified and lime stabilised layer types C4 and C5			
	Cement stabilised pavement (CS)	Sprayed seal over semi-rigid / semi-rigid composite pavement	Fatigue of cemented materials	12	SAR12
		Asphalt over semi-rigid / semi-rigid composite pavement			

Source: Austroads Guide to Pavement Technology Part 2: Pavement Structure Design, 2008

Austroads states that for granular pavements with a thin bituminous surfacing (GN), the SAR calculated with a load damage exponent of 4 is commonly referred to as ESA (i.e. 1 ESA = 1 SAR4). This damage exponent was derived from field studies of pavement performance. The load damage exponents 5 (fatigue of asphalt) and 12 (cemented material) are derived from the fatigue relationships for these materials.

2.1.4 Austroads heavy vehicle classification

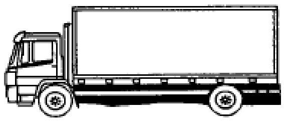
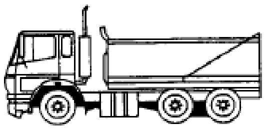
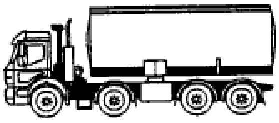
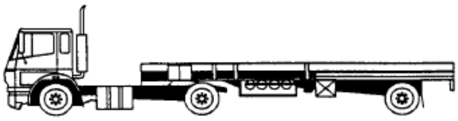
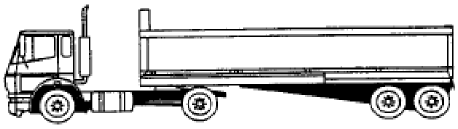
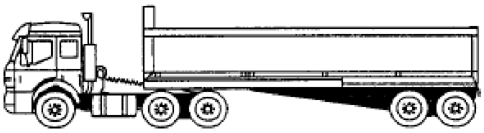
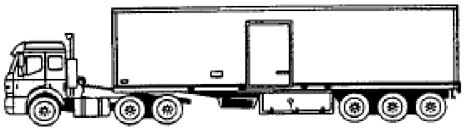
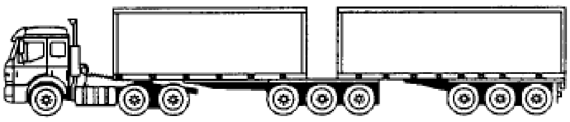
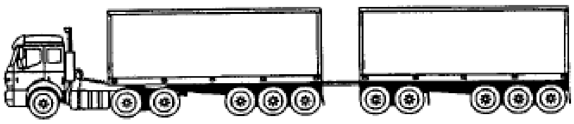
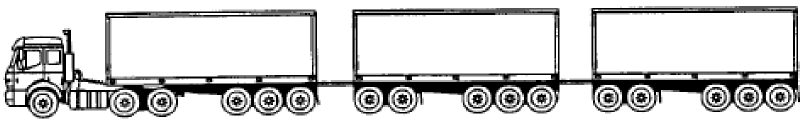
Austroads defines 10 different heavy vehicle classes (i.e. Class 3 to 12), as illustrated in Figure 3.

2.1.5 Austroads axle group type

Austroads defines the following six (6) axle group types:

- single axle with single tyres (SAST)
- single axle with dual tyres (SADT)
- tandem axle with single tyres (TAST)
- tandem axle with dual tyres (TADT)
- triaxle with dual tyres (TRDT)
- quad-axle with dual tyres (QADT).

All heavy vehicles comprise a combination of the above axle group types.

Class	Typical description	Dominant vehicle in each class
Medium (5.5m to 14.5m)		
3	Two axle truck	
4	Three axle truck	
5	Four axle truck	
Long (11.5m to 19.0m)		
6	Three axle articulated	
7	Four axle articulated	
8	Five axle articulated	
9	Six axle articulated (semi-trailer)	
Medium combination (17.5m to 36.5m)		
10	B Double	
11	Double road train	
Large combination (over 33.0m)		
12	Triple road train	

Source: Austroads Guide to Pavement Technology Part 2: Pavement Structure Design, 2008

Figure 3: Austroads vehicle classification system: heavy vehicles

2.1.6 SAR by axle group type

Table 2 provides a summary of loaded and unloaded SAR by axle group type. Note, the loaded SAR values in Table 2 are based on the full payload for each axle group type. If the payload was reduced (i.e. trucks not at 100% of their legal capacity), the SAR value would also reduce.

Table 2: SAR Calculation by axle group type

ID	Axle group type	SAST	SADT	TAST	TADT	TRDT	QADT
-	Axles	Single	Single	Tandem	Tandem	Tri	Quad
-	Tyres	Single	Dual	Single	Dual	Dual	Dual
A	Legal loading (t)	6.0	9.0	11.0	16.5	20.0	27.0
B	Base load per SAR4	5.4	8.2	9.2	13.8	18.5	22.5
C	Unloaded axle group load (t)	4.5	4.0	7.5	5.0	6.5	7.9
-	Unloaded SAR4 = ESAs = $[(C)/(B)]^4$	0.482	0.057	0.442	0.017	0.015	0.015
	Unloaded SAR5 = $[(C)/(B)]^5$	0.402	0.028	0.360	0.006	0.005	0.005
	Unloaded SAR12 = $[(C)/(B)]^{12}$	0.112	0.000	0.086	0.000	0.000	0.000
D	Loaded axle group Load (t)	6.0	9.0	11.0	16.50	20.0	27.0
-	Loaded SAR4 = ESAs = $[(D)/(B)]^4$	1.524	1.451	2.044	2.044	1.366	2.074
-	Loaded SAR5 = $[(D)/(B)]^5$	1.693	1.593	2.444	2.444	1.477	2.488
-	Loaded SAR12 = $[(D)/(B)]^{12}$	3.541	3.056	8.536	8.536	2.549	8.916
-	Payload (t)	1.5	5.0	3.5	11.5	13.5	19.1

Note: one (1) tonne = 9.81 kN
Note: a 'Standard Axle' = a SADT applying an axle load of 80kN to the pavement
Note: refer to Heavy Vehicle (Mass, Dimension and Loading) National Regulation (Part 2) for detailed Legal Loading.

2.1.7 SAR by Austroads heavy vehicle classification

The SAR for a specific heavy vehicle is simply the sum of the SAR for each relevant axle group type. Table 3 provides a summary of loaded and unloaded SAR for the dominant vehicle in each Austroads class. Detailed calculations by axle group type are provided in Appendix A. Note, the loaded SAR values in Table 3 are based on the full payload for each vehicle classification. If the payload was reduced (i.e. trucks not at 100% of their legal capacity), the SAR value would also reduce.

Table 3: SAR calculation by Austroads heavy vehicle classification

Austroads vehicle class	3	4	5	6	7	8	9	10	11	12
Legal Loading (t)	15.0	22.5	27.5	24.0	31.5	39.0	42.5	62.5	79.0	115.5
Base Load per SAR4	13.6	19.2	23.0	21.8	27.4	33.0	37.7	56.2	70.0	102.3
Unloaded Axle Group Load (t)	8.5	9.5	12.5	12.5	13.5	14.5	16.0	22.5	27.5	39.0
Unloaded SAR4	0.54	0.50	0.46	0.60	0.56	0.52	0.51	0.53	0.55	0.58
Unloaded SAR5	0.43	0.41	0.37	0.46	0.44	0.41	0.41	0.42	0.43	0.44
Unloaded SAR12	0.11	0.11	0.09	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Loaded Axle Group Load (t)	15.0	22.5	27.5	24.0	31.5	39.0	42.5	62.5	79.0	115.5
Loaded SAR4	2.98	3.57	4.09	4.43	5.02	5.61	4.93	6.30	8.34	11.75
Loaded SAR5	3.29	4.14	4.89	4.88	5.73	6.58	5.61	7.09	9.53	13.45
Loaded SAR12	6.60	12.08	17.07	9.65	15.13	20.61	14.63	17.17	25.71	36.79
Payload (t)	6.5	13.0	15.0	11.5	18.0	24.5	26.5	40.0	51.5	76.5

Figure 4 graphically demonstrates the relationship between payload and SAR for each Austroads class.

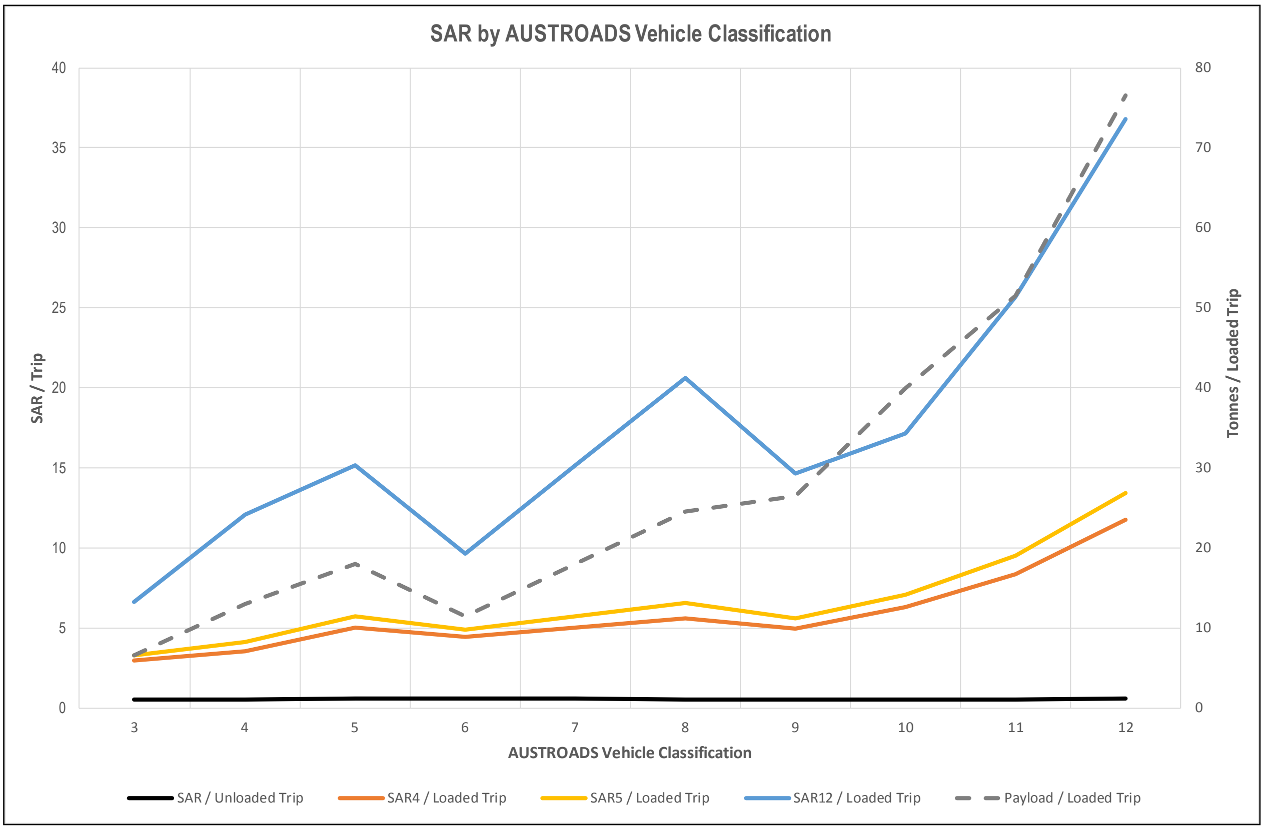


Figure 4: SAR by Austroads heavy vehicle class

2.2 Marginal cost methodology for unsealed roads

2.2.1 Loading units for unsealed roads

TMR has employed a whole of life cycle assessment methodology to cater for unsealed roads which:

- adopts the Australian Local Road Deterioration Study (LRDS) gravel loss model to calculate marginal cost estimates per pair of axle passes (termed Loading Units (LU)) for various combinations of network, comprising surface material performance, regional location (represented in annual rainfall), treatment costs (represented by district) and traffic parameters, and by applying an estimated optimum grading frequency in relation to the anticipated (total) traffic use
- ensures that the level of service experienced by all road users is consistent with the anticipated level of traffic during the period of additional loading
- involves the same steps as for sealed roads except that SAR and SAR-km is replaced by the LU, and the marginal cost is expressed in ‘cents per LU-km’.

There are two (2) methods of calculating LU as follows:

- Method 1: By Austroads class (used for development generated traffic)
- Method 2: By TMR derived vehicle categories (used for background traffic volumes).

2.2.2 LU by Austroads heavy vehicle classification

Using Method 1, LU is calculated as a function of the number of axles, using the following equation:

$$Loading\ Units = \frac{Number\ of\ Axles}{2}$$

Table 4 provides a summary of LU by Austroads heavy vehicle classification. Note, the calculation of LU values is independent of payload. For vehicles operating on unsealed public roads, the damaging effect of a loaded and unloaded vehicle is the same. Therefore, the LU is constant per vehicle class.

Table 4: LU by Austroads heavy vehicle classification

ID	Austroads class	3	4	5	6	7	8	9	10	11	12
[A]	Number of Axles	2	3	4	3	4	5	6	9	11	16
	Loading Units (LU) = (A/2)	1.0	1.5	2.0	1.5	2.0	2.5	3.0	4.5	5.5	8.0

2.2.3 LU by vehicle type

Where specific individual vehicle class data cannot be used, LU is determined by using Method 2, where LU is calculated based on the broad vehicle categories. There are four (4) LU categories as follows:

- Category 1A: Short Vehicles
- Category 1B: Rigid Truck or Bus
- Category 1C: Articulated Vehicles
- Category 1D: Road Trains.

The values for LU by vehicle category are presented in Table 5.

Table 5 LU by vehicle class

Category	Vehicle type	Austroads class	Loading Unit (LU)
1A	Short Vehicles	1, 2	1.00
1B	Rigid Truck or Bus	3, 4, 5	1.10
1C	Articulated Vehicles	6, 7, 8, 9	2.48
1D	Road Trains	10, 11, 12	5.25

2.3 Network statistics

Table 6 provides a summary of the SCR network by pavement type. The vast majority of the sealed SCR network is constructed with GN pavement. The average marginal cost for GN is significantly higher than AC and CS. This is due to the wide variation in the structural capacity of GN pavements, with measured strength values being lower and more variable, and environmental effects.

Table 6: SCR network overview

Type	Length of pavement network	% of network	Average marginal cost	Damage unit
Sealed roads with granular pavement (GN)	24,886 km	82%	13.60 cents / SAR-km	SAR4
Sealed roads with asphaltic concrete pavement (AC)	2,523 km	7%	4.87 cents / SAR-km	SAR5
Sealed roads with cement stabilised pavement (CS)	2,761 km	8%	3.69 cents / SAR-km	SAR12
Sub total	30,171 km	88%	11.94 cents / SAR-km	-
Unsealed roads	4,277 km	12%	14,84 cents / LU-km	LU
Total	34,448 km	100%	-	-

2.4 Scope of impact assessment and HV growth rates

The GTIA defines the ‘impact assessment area’ for pavement impacts as:

> *“all road links where the development SAR4s/LUs exceed 5% of the base traffic in either direction on the link’s SAR4s/LUs in the year of opening of each stage.”*

The GTIA defines the ‘impact assessment year’ for pavement impacts as:

> *“Year of opening of each stage including the final stage. Note that mitigation of pavement impacts occurs for a period of 20 years after the opening of the final stage.”*

Given the above, there is a requirement to forecast future background heavy vehicle demands on relevant SCRs for each year of the project. This can be done by applying site specific historical heavy vehicle annual growth rates (linear) based on data obtained from TMR’s Road Segment Roads (refer Section 3.2 for details). In the absence of site-specific data, an annual growth rate of 3% p.a. should be adopted.

In terms of development traffic demands, quite often these vary during the construction and commissioning phases before settling down to relatively uniform levels during the operational phase. Daily, weekly and monthly variations (if any) in development generated traffic should be reduced to a uniform loading over a 365-day year to be compatible with AADT generated data.

2.5 Motorway ramps

There is currently no marginal cost data for on and off ramps to motorways or highways. If it is determined that development SAR4s exceed 5% of the base traffic on a ramp, it is recommended that the PIA adopts marginal cost rates from the adjacent motorway segment. Note, the applicant may need to obtain baseline traffic count data for impacted ramps.

3. Assessment process for sealed roads

3.1 Step 1: Identify impact assessment area

In relation to pavement impacts, the GTIA defines the 'impact assessment area' as:

"all road links where the development SAR4s exceed 5% of the base traffic in either direction on the link's SAR4s in the year of opening of each stage."

Determining SARs for traffic generated by a specific development on a SCR is a function of heavy vehicle trip generation, trip distribution and route usage. Relevant notes are provided below:

- **Traffic generation** of the development considers the volume of product / goods being moved, the size of vehicles proposed to carry these loads / goods, the load efficiency (for example, due to bulking effects) and the frequency of back loading or return movements. Heavy vehicle traffic needs to be assessed for vehicles both leaving and entering a site.
- **Traffic distribution** of the development generated traffic to its destinations should ideally be based on an understanding of the location to which the product / goods are being delivered. Where this is uncertain at the time of development (for example, for extractive industries, quarries and so on), an estimate of traffic distribution proportions is to be made and justified.
- **Traffic routes** development generated traffic will use depend on a number of factors such as travel time, convenience, typical traffic conditions at different times of the day and heavy vehicle movement restrictions in proximity of the site. Routes can be identified based on travel time comparisons of alternative routes, traffic modelling, local knowledge and so on. In many cases where significant heavy vehicle volumes are generated by a development, the haulage routes are typically known (for example, quarry or mine). Where haulage routes are known with reasonable confidence, these should be mapped to include both origin(s) and destination(s).

In addition to the above, sound engineering judgement should be applied to determine if any other roads, routes or areas may experience development generated heavy vehicle traffic.

All SCRs within the potential impact assessment area are subject to Step 2.

3.2 Step 2: Source road asset data from TMR

Once the potential impact assessment area has been identified, road asset data for the impacted roads will be required to determine if the development SAR4s will exceed 5% of base traffic SAR4s.

Road asset data for the SCR network can be obtained directly from TMR by completing the *Road Asset Data (RAD) Request Form*. A copy of the RAD Request Form is included in **Appendix B**. The RAD form should be emailed to RoadAssetData@tmr.qld.gov.au.

Road Asset Data will include:

- **AADT** recorded for each road section, to be used in Step 3
- **% heavy vehicles** recorded for each road section, to be used in Step 3
- **Marginal cost** recorded for each 100m segment of a SCR, to be used in Step 7
- **Annual (linear) growth rate** recorded for each road section, to be used in Step 3.

Once the above road asset data has been obtained, background SAR4s for relevant SCRs within the impact assessment area are determined in Step 3.

In addition to the above, where highway ramps have been identified within the impact assessment area, traffic volume and heavy vehicle percentage data should be obtained for the relevant sections.

3.3 Step 3: Calculate background SAR4s (ESAs)

The raw road asset data from TMR provides a two-way AADT with a heavy vehicle percentage for each identified road segment. Unfortunately, it is not feasible to calculate background SAR5s and SAR12s as the raw data does not capture loaded and unloaded heavy vehicle movements. As such, the scoping assessment is based on SAR4s (ESAs). This is a reasonable approach noting that 82% of the TMR network is sealed roads with granular pavement (SAR4 / ESA).

In order to estimate background SAR4s (ESAs), the following steps are required:

- **Step 3A:** estimate the directional HV demands
- **Step 3B:** convert the estimated directional HV demands into SAR4s (ESAs).

In relation to Step 3A, there are two (2) options, including:

- **Option A:** utilise the relevant AADT Segment Report provided by TMR
- **Option B:** apply engineering judgement (i.e. 50% eastbound and 50% westbound).

In relation to Step 3B, TMR provide the following standard 'SAR4s (ESAs) per HV' rates based on survey data. Note, these rates are consistent with the 'Fitzroy Methodology' utilised under the GARID.

- **Bruce Highway** = 2.9 SAR4s (ESAs) / HV
- **All other roads** = 3.2 SAR4s (ESAs) / HV.

Using the above methodology, background SAR4s (ESAs) for SCRs within the impact assessment area can be determined. Table 7 provides an overview of example raw AADT data provided by TMR.

Table 7: Example of raw AADT data provided by TMR (sealed roads)

Road name	SECTION_ID	TDIST_START	TDIST_END	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV
Road A	1A	0.00	5.00	60,000	2017	85.00	15.00	51,000	9,000
Road B	2	0.00	1.00	15,000	2017	94.00	6.00	14,100	900

Table 8 provides a summary of the background SAR4s (ESAs) of the roads included in Table 7. For this example, Road A and Road B are the extents of the impact assessment area.

Table 8: Example of estimated background SAR4s / ESAs (sealed roads)

Road name	Direction	TDIST_START	TDIST_END	AADT	%_HV	AADT_HV	Directionality	SAR4_PER_HV	SAR4_PER_DAY
Road A	Westbound	0.00	5.00	60,000	15.00	9,000	50%	3.2	14,400
Road A	Eastbound	5.00	0.00				50%	3.2	14,400
Road B	Northbound	0.00	1.00	15,000	6.00	900	50%	3.2	1,440
Road B	Southbound	1.00	0.00				50%	3.2	1,440

This process is to be completed for all identified road segments within the impact assessment area.

Yearly background SAR4s (ESAs) should be determined by multiplying SAR4_PER_DAY volumes by 365.

Additionally, annual growth rates should be applied to the above data to determine the background SAR4s (ESAs) of each road for the life of the development. Background SAR4s (ESAs) are compared to development SAR4s (ESAs) in Step 6 to identify SCRs with development impacts.

3.4 Step 4: Calculate development SAR4s (ESAs)

Development SAR4s (ESAs) are calculated as a function of the estimated heavy vehicle volumes, vehicle types and vehicle loading status. Relevant considerations include:

- **Heavy vehicle traffic volumes** considers the total number of heavy vehicles movements (i.e. loaded and unloaded) that the development will generate. This should be determined by day and by year (considering number of operating days per year), and should also consider any yield or operational changes throughout the life of the development.
- **Vehicle type** considers the type or class of vehicle(s) used by the development.
- **Vehicle loading Status** considers if the vehicle is loaded or unloaded.

Development generated SAR4s (ESAs) can be determined for a typical day of operation and per year. Table 9: Example of daily development SAR4s (ESAs) (sealed roads)

provides an overview of an example traffic generation, using the below assumptions:

- **Heavy vehicle traffic volumes:** 50 per day (25 inbound + 25 outbound) for life of development
- **Days of operation:** 300 per year
- **Vehicle type:** 100% Class 9 Semi-Trailer
- **Vehicle loading:** Inbound = 100% loaded, Outbound = 100% unloaded.

Table 9: Example of daily development SAR4s (ESAs) (sealed roads)

Vehicle class	Loaded			Unloaded			Total
	Daily demand	SAR4_PER_VEH	SAR4_PER_DAY	Daily demand	SAR4_PER_VEH	SAR4_PER_DAY	
Class 9	25 vehicles per day	4.93 (refer Table 3)	123.25	25 vehicles per day	0.51 (refer Table 3)	12.75	136

Table 10 provides an overview of an example yearly development traffic generation.

Table 10: Example of yearly development SAR4s (ESAs) (sealed roads)

Vehicle class	Loaded			Unloaded			Total
	Annual demand	SAR4_PER_VEH	SAR4_PER_DAY	Volume	SAR4_PER_VEH	SAR4_PER_DAY	
Class 9	7,500 vehicles per year	4.93 (refer Table 3)	36,975	7,500 vehicles per year	0.51 (refer Table 3)	3,825	40,800

Once development generated SAR4s (ESAs) have been calculated, directional distribution with respect to the SCR network is determined in Step 5.

3.5 Step 5: Assign development SAR4s (ESAs) onto the SCR network

Development SAR4s (ESAs) should then be applied to the sections of the SCR network identified in Step 1. This should consider network distribution and directionality. Relevant notes are provided below:

- **Network distribution:** is the percentage of development generated volumes which will travel on each identified SCR road within the impact assessment area.
- **Directionality:** is the direction development generated volumes will travel on each identified SCR within the impact assessment area. This should also consider vehicle loading status.

Using the above methodology, development generated SAR4s (ESAs) can be determined for each SCR identified within the impact assessment area. Table 11 provides an overview of an example daily development traffic distribution, using the below assumptions:

- **Road A westbound:** 100% of loaded volumes will travel in this direction
- **Road A eastbound:** 100% of unloaded volumes will travel in this direction
- **Road B northbound:** 100% of loaded volumes will travel in this direction
- **Road B southbound:** 100% of unloaded volumes will travel in this direction.

Table 11: Example of development traffic distribution

Road data				Development volumes		
Road name	Direction	Section	SAR4_PER_YEAR	% distribution	Load	SAR4_PER_YEAR
Road A	Westbound	0.00 – 5.00	5,256,000	100%	Loaded	36,975
Road A	Eastbound	5.00 – 0.00	5,256,000	100%	Unloaded	3,825
Road B	Northbound	0.00 – 1.00	525,600	100%	Loaded	36,975
Road B	Southbound	1.00 – 0.00	525,600	100%	Unloaded	3,825

Once development generated SAR4s (ESAs) distributions have been determined, SCRs with development impacts (i.e. >5% development SAR4 (ESAs) impact) are identified in Step 6.

3.6 Step 6: Identify road links with >5% development SAR4s (ESAs) impact

As outlined in Step 1, development impacts are identified where development generated SAR4s (ESAs) exceed 5% of background SAR4s (ESAs) on the SCR network.

To determine where >5% impacts occur, the development generated SAR4s (ESAs) on each SCR (Step 5) are compared to background SAR4s (ESAs) on each SCR (Step 3) within the impact assessment area. This should be undertaken for each year of operation to determine the number of years impacts will occur.

Table 12 provides an overview of an example SAR4 (ESAs) comparison to determine 5% impacts.

Table 12: Example of yearly development traffic >5% impacts assessment

Road name	Direction	Section	Background _SAR4_PER _DAY	Development _SAR4_PER_ DAY	% background	>5%
Road A	Westbound	0.00 – 5.00	5,256,000	36,975	0.70%	No
Road A	Eastbound	5.00 – 0.00	5,256,000	3,825	0.07%	No
Road B	Northbound	0.00 – 1.00	525,600	36,975	7.03%	Yes
Road B	Southbound	1.00 – 0.00	525,600	3,825	0.73%	No

Based on the above example, development SAR4s (ESAs) exceed 5% for Road B Northbound only, and further analysis of only this section of the SCR network is required.

Once relevant sections of the SCR network with SAR4 (ESAs) impacts have been identified (i.e. >5% background SAR4s (ESAs)), development contributions to offset impacts are determined in Step 7.

3.7 Step 7: Calculate contribution to offset development impacts

Development contributions are required for all roads within the SCR network where development generated SAR4s (ESAs) exceed 5% of background SAR4s (ESAs) (see Step 6).

The contribution is determined using development generated SARs (i.e. SAR4, SAR5 and SAR12) and road marginal cost. Relevant notes are provided below:

- **Development generated SARs:** are the development generated SAR4s (see Step 5) with allowance for the exponential load damage by different pavement type.
  Note: the methodology to calculate SARs in this step is generally as per Step 5. The only difference is that SARs in this step account for the exponential load damage by different pavement type (i.e. granular pavement (SAR4), asphaltic concrete (SAR5), and cement stabilised pavements (SAR12)).
- **Road marginal cost:** is a cost per 100m segment of road derived over a 50-year cycle of road costings (including maintenance, rehabilitation and reconstruction). The marginal costs for each segment in the identified impact assessment area is provided with road asset data (see Step 2).

The contribution is calculated in cents per SAR-km.

Table 13 provides an overview of an example development contribution calculation.

Table 13: Example of development contribution calculations

SECTION_ID	Direction	Section	Length (km)	Pavement type	Load damage exponent	Marginal cost (CENTS_PER_SAR-km)	DEVELOPMENT_ VOLUMES_PER_YEAR	SAR_PER_TRIP (CLASS 9 (LOADED)) (REFER TO TABLE 2.3)	DEVELOPMENT_SAR PER_YEAR	Development contribution ($)
01	Northbound	0.00 – 0.10	0.1	GN	4	8.37	7,500	4.93	36,975	$309.48
02	Northbound	0.10 – 0.20	0.1	GN	4	16.14	7,500	4.93	36,975	$596.78
03	Northbound	0.20 – 0.30	0.1	GN	4	16.14	7,500	4.93	36,975	$596.78
04	Northbound	0.30 – 0.40	0.1	AC	5	1.43	7,500	5.61	42,075	$60.17
05	Northbound	0.40 – 0.50	0.1	AC	5	3.42	7,500	5.61	42,075	$143.90
06	Northbound	0.50 – 0.60	0.1	AC	5	5.88	7,500	5.61	42,075	$247.40
07	Northbound	0.60 – 0.70	0.1	CS	12	2.10	7,500	14.63	109,725	$230.42
08	Northbound	0.70 – 0.80	0.1	CS	12	3.16	7,500	14.63	109,725	$346.73
09	Northbound	0.80 – 0.90	0.1	CS	12	4.03	7,500	14.63	109,725	$442.19
10	Northbound	0.90 – 1.00	0.1	CS	12	4.03	7,500	14.63	109,725	$442.19
Total			**1.0**	**-**	**-**	**-**	**-**	**-**	**-**	**$3,416.04**

In summary, based on the above example, the development would be required to contribute $3,416.04 per year of operation to offset development impacts on Road B Northbound.

Using the above methodology, the contribution should be calculated for each road segment where impacts of >5% were identified. This should be totalled to provide a contribution rate per year of operation.

4. Assessment Process for Unsealed Roads

4.1 Step 1: Identify impact assessment area

As per Step 1 for sealed roads (refer Section 3.1).

4.2 Step 2: Source road asset data from TMR

As per Step 2 for sealed roads (refer Section 3.2).

4.3 Step 3: Calculate background LUs

The raw road asset data from TMR includes a two-way AADT with a heavy vehicle percentage for each identified road segment and provides a breakdown of HV volumes along the identified road segment.

This data is used to calculate the background LUs on the identified road segment using the following steps:

- **Step 3A**: determine the LV and HV demands (two-way) by vehicle on each identified road
- **Step 3B:** convert the LV and HV demands into LUs.

For Step 3A, the relevant data from TMR should be used. For Step 3B, Table 14 provides the LU rates for each TMR derived vehicle category.

Table 14: LU by vehicle category

Category	Vehicle type	Austroads class	Loading unit (LU)
1A	Short Vehicles	1, 2	1.00
1B	Rigid Truck or Bus	3, 4, 5	1.10
1C	Articulated Vehicles	6, 7, 8, 9	2.48
1D	Road Trains	10, 11, 12	5.25

Using the above methodology, background LUs for relevant SCRs within the assessment area can be determined. Table 15 provides an example of raw AADT data provided by TMR for unsealed roads.

Table 15: Example of raw AADT data provided by TMR (unsealed roads)

Road name	SECTION_ID	TDIST_START	TDIST_END	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV	ADT_HV_1A	AADT_HV_1B	AADT_HV_1C	AADT_HV_1D
Road A	100A	0.00	5.00	600	2017	85.00	15.00	510	90	510	30	30	30
Road B	201	0.00	1.00	150	2017	94.00	6.00	141	9	141	3	3	3

Table 16 provides a summary of the background LUs of the roads included in Table 15. For this example, Road A and Road B are the extents of the assessment area. It is also noted that the raw data has not been split based on directionality as unsealed roads are typically undivided carriageways.

Table 16: Example of estimated background LUs (unsealed roads)

Road name	Category 1A RATE = 1.00 LUs_PER_HV	Category 1B RATE = 1.10 LUs_PER_HV	Category 1C RATE = 2.48 LUs_PER_HV	Category 1D RATE = 5.25 LUs_PER_HV	LU_PER_DAY
Road A	510	33	74.4	157.5	**774.9**
Road B	141	3.3	7.44	15.75	**167.49**

This process is to be completed for all identified road segments within the impact assessment area. Yearly background LUs should be determined by multiplying LU_PER_DAY volumes by 365 days per year. Additionally, annual growth rates should be applied to the above data to determine the background LUs of each road for the life of the development. Background LUs are compared to development LUs in Step 6 to identify SCRs with development impacts.

4.4 Step 4: Calculate development LUs

Development LUs are calculated as a function of all vehicle traffic volumes, vehicle types and number of axles per vehicle. Relevant notes are provided below:

- **All vehicle traffic volumes**: considers the total number of all vehicles movements that the development will generate. This should be determined by day and by year (considering number of operating days per year) and should also consider any yield / operation changes throughout the life of the development.
- **Vehicle type**: considers the type or class of vehicle(s) used by the development.
- **Number of axles per vehicle**: considers the number of axles per each vehicle type.

Using the above methodology, development generated LUs can be determined per typical day of operation and per year. Table 17 provides an example of daily development traffic generation in terms of LUs, using the below assumptions:

- **Light vehicle traffic volumes:** 4 per day (Class 1 (Car)) for life of development
- **Heavy vehicle traffic volumes:** 4 per day (Class 9 (Semi-Trailer) for life of development
- **Days of operation:** 300 per year.

Table 17: Example of daily development LUs

Vehicle class	VEHICLES_PER_DAY	Loading units	LU_PER_DAY
Class 1	4	1 (refer Table 5)	4
Class 9	4	3 (refer Table 5)	12

Table 18 provides an example of yearly development traffic generation in terms of LUs.

Table 18: Example of yearly development LUs

Vehicle class	VEHICLES_PER_DAY	Loading units	LU_PER_DAY
Class 9	1,200	1 (refer Table 5)	1,200
Class 9	1,200	3 (refer Table 5)	3,600
Total	**-**	**-**	**4,800**

Once development generated LUs have been calculated, directional distribution with respect to the SCR network is determined in Step 5.

4.5 Step 5: Assign development LUs onto the SCR network

Development LUs should then be applied to the relevant sections of the SCR network identified in Step 1. This application should only consider network distribution. Relevant notes are provided below:

- **Network distribution** is the percentage of development generated volumes which will travel on each identified road in the SCR network.

Using the above methodology, development-generated LUs can be determined for each SCR identified within the assessment area. Table 19 provides an overview of an example daily development traffic distribution, using the below assumptions:

- **Road A:** 100% of development generated volumes will travel on this road
- **Road B:** 100% of development generated volumes will travel on this road.

Table 19: Example of development traffic distribution

Road data				Development volumes		
Road name	Section	LU_PER_DAY	LU_PER_YEAR	% distribution	LU_PER_DAY	LU_PER_YEAR
Road A	0.00 – 5.00	774.9	282,839	100%	16	4,800
Road B	0.00 – 1.00	167.49	61,134	100%	16	4,800

Once development generated LUs distributions have been determined, SCR's with development impacts are identified in Step 6.

4.6 Step 6: Identify road links with >5% development LUs impact

As outlined in Step 1, development impacts are identified where development generated LUs exceed 5% of background LUs on the SCR network.

To determine where >5% impacts occur, the development generated LUs on each SCR (Step 5) is compared to background LUs on each SCR (Step 3) within the assessment area. This should be undertaken for each year of operation to determine the number of years impacts will occur.

Table 20 provides an overview of an example LU comparison to determine 5% impacts.

Table 20: Example of yearly development traffic >5% impacts assessment

Road name	section	BACKGROUND_LU_PER_YEAR	DEVELOPMENT_LU_PER_YEAR	% background	>5%
Road A	0.00 – 5.00	282,839	4,800	1.70%	No
Road B	0.00 – 1.00	61,134	4,800	7.85%	Yes

Based on the above example, development LUs exceed 5% for Road B only and further analysis of only this section of the SCR network is required.

Once relevant sections of the SCR network with LU impacts have been identified (i.e. >5% background LUs), development contribution requirements to offset impacts are determined in Step 7.

4.7 Step 7: Calculate contribution to offset development impacts

Development contributions are required for all roads within the SCR network where development generated LUs exceed 5% of background LUs (see Step 6).

The contribution is determined using the roads marginal cost. Relevant notes are provided below:

- **Road marginal cost** is a cost per 100m segment of road derived over a 50-year cycle of road costings (including maintenance, rehabilitation and reconstruction). The marginal costs for each segment in the identified impact area is provided with road asset data (see Step 2).

The contribution is calculated in cents per LU-km.

Table 21 provides an overview of an example development contribution calculation.

Table 21: Example of development contribution calculations (unsealed road)

SECTION_ID	Section	Length (km)	Marginal cost (CENTS_PER_LU-km)	DEVELOPMENT_VOLUMES_PER_YEAR	DEVELOPMENT_LUs PER_YEAR (refer to Table 2.4)	Development contributions ($)
01	0.00 – 0.10	0.1	8.37	1,600	4,800	$40.18
02	0.10 – 0.20	0.1	8.37	1,600	4,800	$40.18
03	0.20 – 0.30	0.1	8.37	1,600	4,800	$40.18
04	0.30 – 0.40	0.1	5.88	1,600	4,800	$28.22
05	0.40 – 0.50	0.1	5.88	1,600	4,800	$28.22
06	0.50 – 0.60	0.1	5.88	1,600	4,800	$28.22
07	0.60 – 0.70	0.1	5.88	1,600	4,800	$28.22
08	0.70 – 0.80	0.1	6.50	1,600	4,800	$31.20
09	0.80 – 0.90	0.1	6.50	1,600	4,800	$31.20
10	0.90 – 1.00	0.1	6.50	1,600	4,800	$31.20
Total		**1.0**	**-**	**1,600**	**4,800**	**$327.02**

In summary, based on the above example, the development would be required to contribute $327.02 per year of operation to offset impacts on Road B.

Using the above methodology, the contribution should be calculated for each road segment where impacts of >5% were identified. This should be totalled to provide a contribution rate per year of operation.

5. Worked Examples

The following worked examples are for illustrative purposes only. They do not relate to real proposals for development/use at the locations. They also do not consider any other engineering or planning elements.

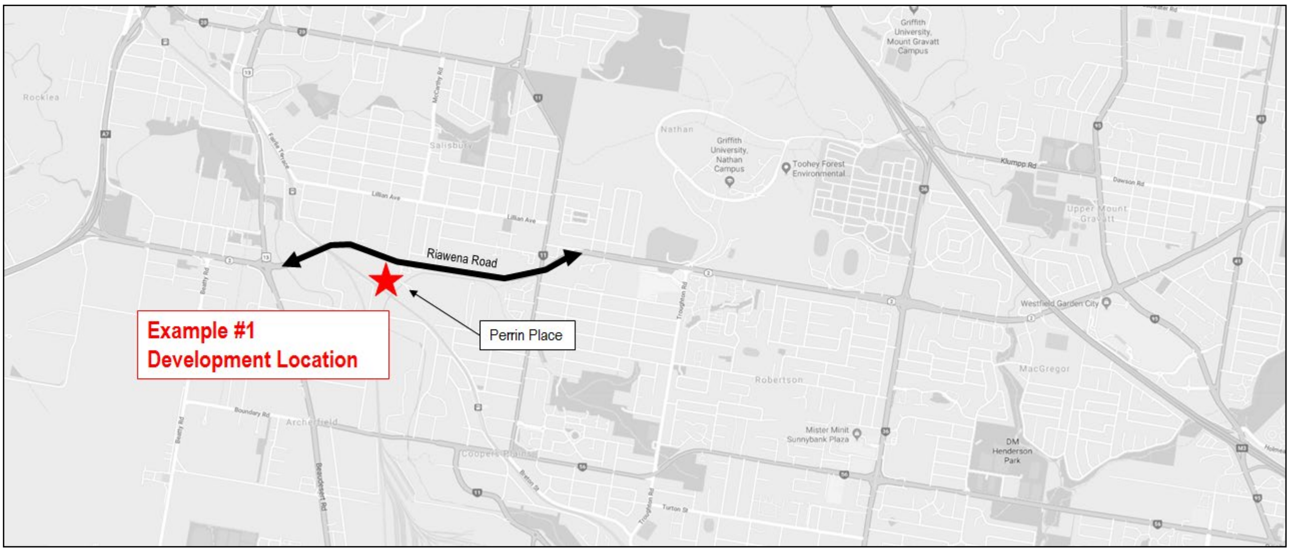
5.1 Example #1: Minor development in urban area (sealed pavement)

Overview

Relevant details for Example #1 are summarised below:

- **Case study aim**: to demonstrate a scenario where a development generates heavy vehicle traffic demands but does not trigger a pavement impact assessment (i.e. <5% background SAR4s / ESAs).
- **Development type:** Tyre Recycling.
- **Development yield:** 20,000 tonnes per year for 20 years (opening in 2020).
- **Location:** Perrin Place, Salisbury (access to U20 – GRIFFITH ARTERIAL ROAD).

The location of the subject site is shown in Figure 5.



Map data: Google, 2018.

Figure 5: Example #1 – Site location overview

Step 1: Impact assessment area

Relevant details regarding the development generated traffic for Example #1 are summarised below:

- **Traffic generation:** development will generate four (4) Semi-Trailer (Class 9) vehicles per day which equates to eight (8) trips per day (i.e. four (4) inbound trips and four (4) outbound trips per day).
- **Traffic distribution:** development traffic will be split 50/50 to/from east and west on Riawena Road.

- **Traffic routes:** development traffic will utilise Riawena Road / Grenard Road to access the Ipswich Motorway and Riawena Road / Kessels Road / Mains Road / Logan Road to access the Pacific Motorway.

Based on the above, the potential impact assessment area is defined as:

- Griffith Arterial Road | Road ID: U20 | TDIST: 0.00-7.41
- Nathan Connection Arterial Road | Road ID: U21 | TDIST 0.00-0.82
- Logan Sub-Arterial Road | Road ID: U90 | TDIST: 0.00-1.64.

Step 2: Source road asset data from TMR

Road asset data is sourced from TMR for the above study area. Table 22 presents relevant data.

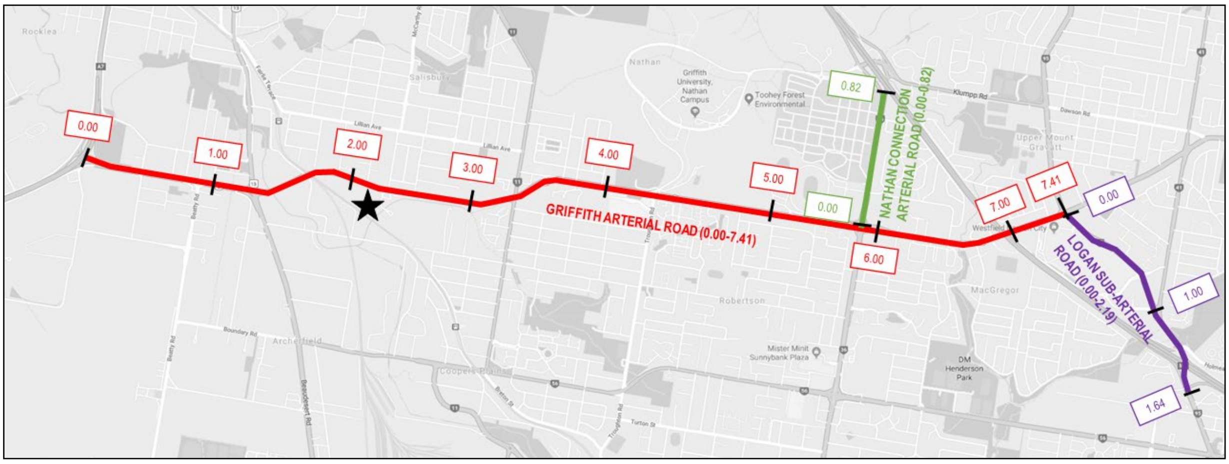
Table 22: Example #1: road asset data provided by TMR

Road name	SECTION_ID	TDIST_START	TDIST_END	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV	SAR4_PER_HV
Griffith Arterial Road	U20	0.00	1.31	58,245	2017	80.83	19.17	47,079	11,166	3.2
		1.31	3.30	35,698	2017	88.85	11.15	31,718	3,980	3.2
		3.30	4.35	37,175	2017	89.55	10.45	33,290	3,885	3.2
		4.35	5.91	46,626	2017	91.94	8.06	42,868	3,758	3.2
		5.91	7.41	54,193	2017	91.7	8.30	49,695	4,498	3.2
Nathan Connection Arterial Road	U21	0.00	0.82	62,155	2017	95.22	4.78	59,184	2,971	3.2
Logan Sub-Arterial Road	U90	0.00	0.99	25,697	2017	95.26	4.74	24,479	1,218	3.2
		0.99	2.19	39,788	2017	95.26	4.74	37,902	1,886	3.2

Growth rate data was not provided, therefore <u>a 3% annual (linear) growth rate has been adopted</u>. A heavy vehicle directional split of 50% in each direction has been adopted.

Step 3: Calculate background SAR4s (ESAs)

Figure 6 shows the relevant roads and chainage.



Map data: Google, 2018.

Figure 6: Example #1 – Key roads

Background SAR4s (ESAs) are calculated in Table 23.

Table 23: Example #1: Background SAR4s (ESAs)

Road name	Direction	TDIST_START	TDIST_END	AADT	% HV	AADT_HV	Directionality	SAR4_PER_HV	SAR4_PER_DAY_2017	SAR4_PER_DAY_2020	SAR4_PER_YEAR_2020
Griffith Arterial Road	Eastbound	0.00	1.31	58,245	19.17	11,166	50%	3.2	17,866	19,474	7,108,010
	Westbound	1.31	0.00				50%	3.2	17,866	19,474	7,108,010
	Eastbound	1.31	3.30	35,698	11.15	3,980	50%	3.2	6,368	6,941	2,533,465
	Westbound	3.30	1.31				50%	3.2	6,368	6,941	2,533,465
	Eastbound	3.30	4.35	37,175	10.45	3,885	50%	3.2	6,216	6,775	2,472,875
	Westbound	4.35	3.30				50%	3.2	6,216	6,775	2,472,875
	Eastbound	4.35	5.91	46,626	8.06	3,758	50%	3.2	6,013	6,554	2,392,210
	Westbound	5.91	4.35				50%	3.2	6,013	6,554	2,392,210
	Eastbound	5.91	7.41	54,193	8.30	4,498	50%	3.2	7,197	7,845	2,863,425
	Westbound	7.41	5.91				50%	3.2	7,197	7,845	2,863,425
Nathan Connection Arterial Road	Northbound	0.00	0.82	62,155	4.78	2,971	50%	3.2	4,754	5,182	1,891,430
	Southbound	0.82	0.00				50%	3.2	4,754	5,182	1,891,430
Logan Sub-Arterial Road	Northbound	0.00	0.99	25,697	4.78	1,218	50%	3.2	1,949	2,124	775,260
	Southbound	0.99	0.00				50%	3.2	1,949	2,124	775,260
	Northbound	0.99	2.19	39,788	4.78	1,886	50%	3.2	3,018	3,290	1,200,850
	Southbound	2.19	0.99				50%	3.2	3,018	3,290	1,200,850

Step 4: Calculate development SAR4s (ESAs)

Relevant details regarding the development SAR4s (ESAs) for Example #1 are summarised below:

- **Vehicle type:** 100% Class 9 Semi-Trailer
- **Heavy vehicle traffic volumes:** eight (8) trips per day (i.e. four (4) inbound + four (4) outbound)
- **Days of operation:** 365 per year
- **Vehicle loading:** Inbound = 100% loaded, Outbound = 100% unloaded.

Development SAR4s (ESAs) are calculated in Table 24.

Table 24: Example #1: Development generated SAR4s (ESAs)

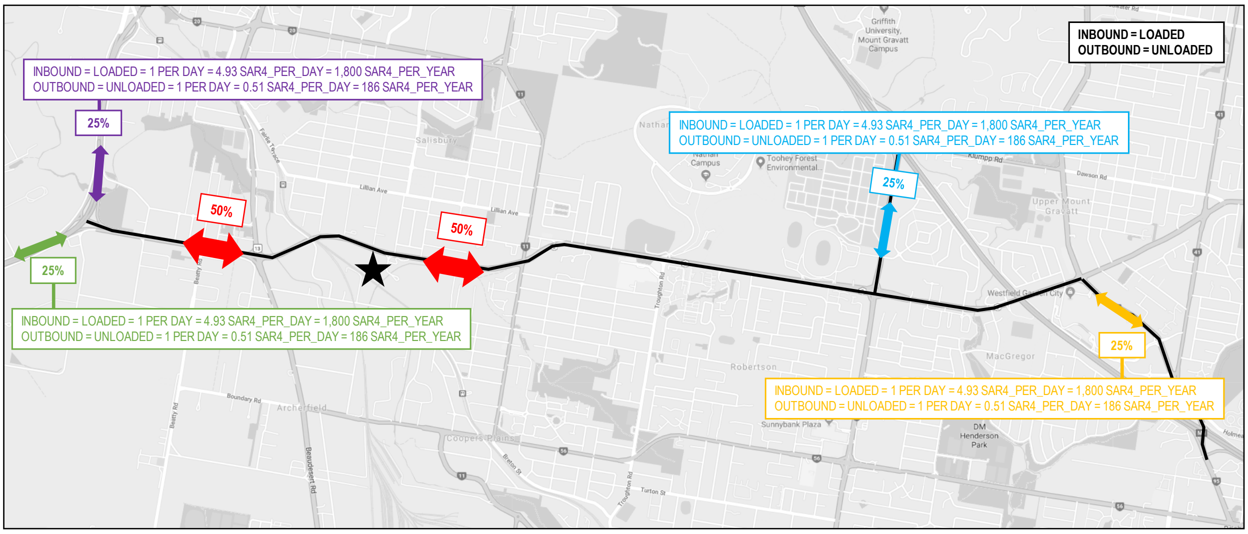
Vehicle class	Loaded				Unloaded				TOTAL_YEAR
	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	
Class 9	4	4.93	19.72	7197.8	4	0.51	2.04	744.6	7942.4

Step 5: Assign development SAR4s (ESAs) onto the SCR network

Relevant details regarding network distribution for Example #1 are summarised below:

- 25% to / from north west, via Ipswich Motorway, Granard Road and Riawena Road
- 25% to / from south west, via Ipswich Motorway, Granard Road and Riawena Road
- 25% to / from north east, via Pacific Motorway, Mains Road, Kessels Road and Riawena Road
- 25% to / from south east, via Pacific Motorway, Logan Road, Kessels Road and Riawena Road.

Figure 7 shows development distribution.



Map data: Google, 2018.

Figure 7: Example #1 – Development distribution

As outlined above, all inbound vehicles will be loaded and all outbound vehicles will be unloaded. Development traffic distribution is calculated in Table 25 for the year of opening (2020).

Table 25: Example #1 – Development - traffic distribution

Road data					Development volumes		
Road name	Direction	TDIST_START	TDIST_END	SAR4_PER_YEAR_2020	% distribution	Load status class 9	SAR4_PER_YEAR_2020
Griffith Arterial Road	Eastbound	0.00	1.31	7,108,010	50%	Loaded	3,598.9
	Westbound	1.31	0.00	7,108,010	50%	Unloaded	372.3
	Eastbound	1.31	3.30	2,533,465	100%	Both	7,942.4
	Westbound	3.30	1.31	2,533,465	100%	Both	7,942.4
	Eastbound	3.30	4.35	2,472,875	50%	Unloaded	372.3

Road data					Development volumes		
Road name	Direction	TDIST_ START	TDIST _END	SAR4_PER_ YEAR_2020	% distribution	Load status class 9	SAR4_PER_ YEAR_2020
	Westbound	4.35	3.30	2,472,875	50%	Loaded	3,598.9
	Eastbound	4.35	5.91	2,392,210	50%	Unloaded	372.3
	Westbound	5.91	4.35	2,392,210	50%	Loaded	3,598.9
	Eastbound	5.91	7.41	2,863,425	25%	Unloaded	186.15
	Westbound	7.41	5.91	2,863,425	25%	Loaded	1,799.45
Nathan Connection Arterial Road	Northbound	0.00	0.82	1,891,430	25%	Unloaded	186.15
	Southbound	0.82	0.00	1,891,430	25%	Loaded	1,799.45
Logan Sub-Arterial Road	Northbound	0.00	0.99	775,260	25%	Loaded	1,799.45
	Southbound	0.99	0.00	775,260	25%	Unloaded	186.15
	Northbound	0.99	2.19	1,200,850	25%	Loaded	1,799.45
	Southbound	2.19	0.99	1,200,850	25%	Unloaded	186.15

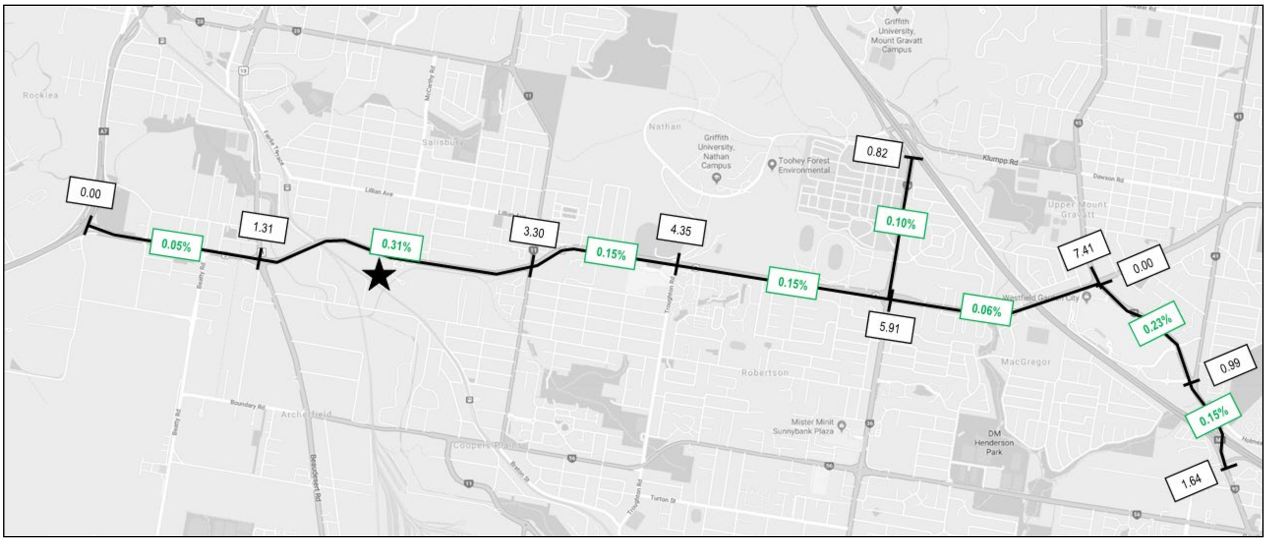
Step 6: Identify road links with >5% development SAR4 (ESAs) impact

Road links with significant (>5%) impacts during the year of opening (2020) are determined in Table 26.

Table 26: Example #1 – Road link impacts

Road name	Direction	TDIST_START	TDIST_END	Background SAR4_PER_YEAR_2020	Development SAR4_PER_ YEAR_2020	Development impacts (%)	>5% impacts
Griffith Arterial Road	Eastbound	0.00	1.31	7,108,010	3598.9	0.05%	No
	Westbound	1.31	0.00	7,108,010	372.3	0.01%	No
	Eastbound	1.31	3.30	2,533,465	7942.4	0.31%	No
	Westbound	3.30	1.31	2,533,465	7942.4	0.31%	No
	Eastbound	3.30	4.35	2,472,875	372.3	0.02%	No
	Westbound	4.35	3.30	2,472,875	3598.9	0.15%	No
	Eastbound	4.35	5.91	2,392,210	372.3	0.02%	No
	Westbound	5.91	4.35	2,392,210	3598.9	0.15%	No
	Eastbound	5.91	7.41	2,863,425	186.15	0.01%	No
	Westbound	7.41	5.91	2,863,425	1799.45	0.06%	No
Nathan Connection Arterial Road	Northbound	0.00	0.82	1,891,430	186.15	0.01%	No
	Southbound	0.82	0.00	1,891,430	1799.45	0.10%	No
Logan Sub-Arterial Road	Northbound	0.00	0.99	775,260	1799.45	0.23%	No
	Southbound	0.99	0.00	775,260	186.15	0.02%	No
	Northbound	0.99	2.19	1,200,850	1799.45	0.15%	No
	Southbound	2.19	0.99	1,200,850	186.15	0.02%	No

Figure 8 shows development impacts. No road links have been identified where development volumes will have significant impacts (i.e. >5%) during the year of opening (2020). Therefore, further no further assessment is required.



Map data: Google, 2018.

Figure 8: Example #1 – Development impacts

Step 7: Calculate contribution to offset development impacts

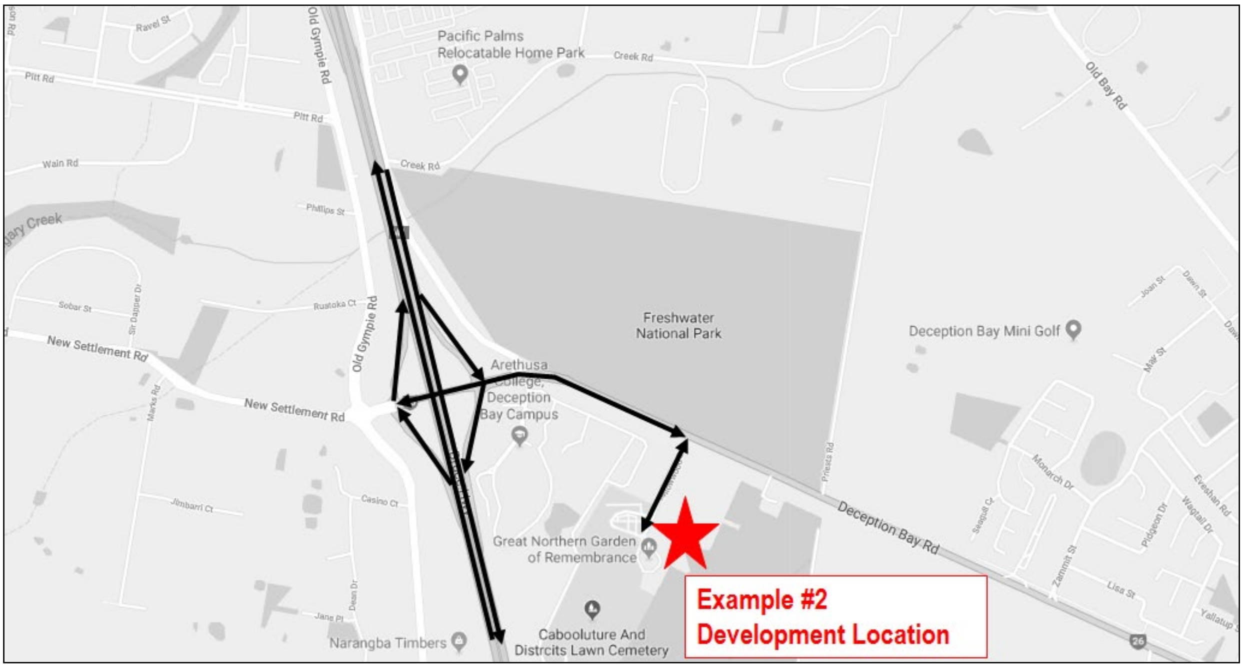
Not Required.

5.2 Example #2: Major development in urban area (sealed pavement)

Overview

Relevant details for Example #2 are summarised below:

- **Case study aim:** to demonstrate a scenario where a development generates significant heavy vehicle demands, and a pavement impact assessment is triggered (i.e. >5% background SAR4s / ESAs).
- **Development type:** Asphalt Plant.
- **Development yield:** 500,000 tonnes per year for 30 years (opening 2020).
- **Location:** Tallowwood Drive, Deception Bay (access to 121 – Deception Bay Road).



Map data: Google, 2018.

Figure 9: Example #2 – Site location overview

Step 1: Impact potential assessment area

Relevant details regarding the development generated traffic for Example #2 are summarised below:

- **Traffic generation:** development will generate:
  - 25 HRV (Class 4) vehicles per day (i.e. 50 trips per day)
  - 50 B-Double (Class 10) vehicles per day (i.e. 100 trips per day).
- **Traffic distribution:** development traffic will be 100% to/from the Bruce Highway
- **Traffic routes:** development traffic will use Deception Bay Road to access the Bruce Highway (north and south).

Based on the above, the potential impact assessment area is defined as:

- Deception Bay Road | Road ID: 121 | TDIST: 0.13-1.20
- Bruce Highway (Brisbane – Gympie) | Road ID: 10A | TDIST: 9.73-17.96.

Step 2: Source road asset data from TMR

Road asset data is sourced from TMR for the above study area. Table 27 presents relevant data.

Table 27: Example #2 – Road asset data provided by TMR

Road Name	SECTION_ID	TDIST_START	TDIST_END	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV	SAR4 _PER_HV
Deception Bay Road	121	0.13	0.40	26,568	2017	95.78	4.22	25,447	1,121	3.2
		0.40	0.55	21,286	2017	93.91	6.09	19,990	1,296	3.2
		0.55	1.64	20,150	2017	94.37	5.63	19,016	1,134	3.2
Bruce Highway	10A	9.73	13.50	106,101	2017	92.17	7.83	97,793	8,308	2.9
		13.50	17.96	113,312	2017	89.79	10.21	101,743	11,569	2.9

Data for the on-ramps and off-ramps to the Bruce Highway is not included in the TMR dataset. As such, traffic surveys were undertaken to obtain background traffic data for the on-ramps and off-ramps to the Bruce Highway. Table 28 presents relevant data.

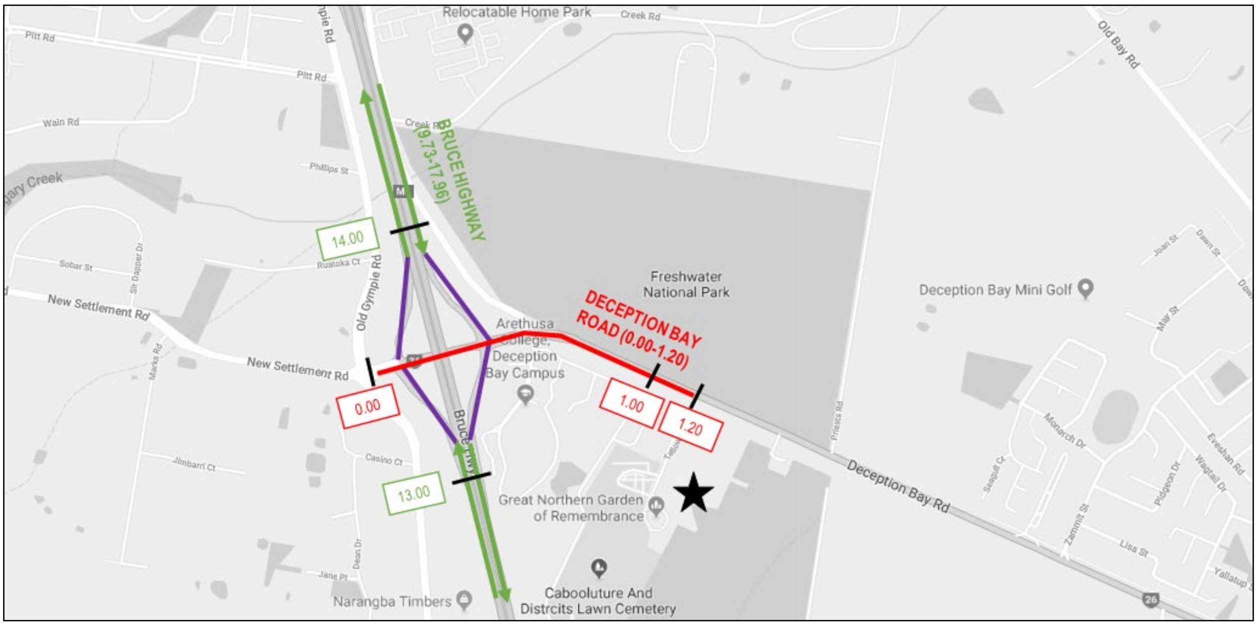
Table 28: Example #2 – Traffic survey data

Road Name	SECTION_ID	RAMP	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV	SAR4_PER_ HV
Bruce Highway	10A	Southbound off-ramp	8,000	2017	95.00	5.00	7600	400	2.9
		Southbound on-ramp	14,000	2017	95.00	5.00	13,300	700	2.9
		Northbound off-ramp	14,000	2017	95.00	5.00	13,300	700	2.9
		Northbound on-ramp	8,000	2017	95.00	5.00	7600	400	2.9

Growth rate data was not provided, therefore a 3% annual (linear) growth rate has been adopted. A heavy vehicle directional split of 50% in each direction has been adopted.

Step 3: Calculate background SAR4s (ESAs)

Figure 10 shows the relevant roads and chainage.



Map data: Google, 2018.

Figure 10: Example #2 – Key roads

Background SAR4s (ESAs) are calculated in Table 29.

Table 29: Example #2 – Background SAR4s (ESAs)

Road name	Direction	TDIST_START	TDIST_END	AADT	% HV	AADT_HV	Directionality	SAR4_PER_HV	SAR4_PER_DAY_2017	SAR4_PER_DAY_2020	SAR4_PER_YEAR_2020
Deception Bay Road	Eastbound	0.13	0.40	26,568	4.22	1,121	50%	3.2	1,794	1,955	713,575
	Westbound	0.40	0.13				50%	3.2	1,794	1,955	713,575
	Eastbound	0.40	0.55	21,286	6.09	1,296	50%	3.2	2,074	2,261	825,265
	Westbound	0.55	0.40				50%	3.2	2,074	2,261	825,265
	Eastbound	0.55	1.64	20,150	5.63	1,134	50%	3.2	1,814	1,977	721,605
	Westbound	1.64	0.55				50%	3.2	1,814	1,977	721,605
Bruce Highway	Northbound	9.73	13.50	106,101	7.83	8,308	50%	2.9	12,047	13,131	4,792,815
	Southbound	13.50	9.73				50%	2.9	12,047	13,131	4,792,815
	Northbound	13.50	17.96	113,312	10.21	11,569	50%	2.9	16,775	18,285	6,674,025
	Southbound	17.96	13.50				50%	2.9	16,775	18,285	6,674,025
	Southbound off-ramp	0.00	0.50	8,000	5.00	400	100%	2.9	1,160	1,264	461,360
	Southbound on-ramp	0.00	0.50	14,000	5.00	700	100%	2.9	2,030	2,213	807,745
	Northbound off-ramp	0.00	0.50	14,000	5.00	700	100%	2.9	2,030	2,213	807,745
	Northbound on-ramp	0.00	0.50	8,000	5.00	400	100%	2.9	1,160	1,264	461,360

Step 4: Calculate development SAR4s (ESAs)

Relevant details regarding the development SAR4s (ESAs) for Example #2 are summarised below:

- **Vehicle type:** 80% Class 10 (B-Double) and 20% Class 4 (HRV)
- **Heavy vehicle traffic volumes:**
  - 50 Class 4 (HRV) trips per day (25 inbound + 25 outbound)
  - 100 Class 10 (B-Double) trips per day (50 inbound + 50 outbound).
- **Days of operation:** 300 per year
- **Vehicle loading:**
  - Class 4 (HRV): Inbound = 100% unloaded, Outbound = 100% loaded
  - Class 10 (B-Double): Inbound = 100% loaded, Outbound = 100% unloaded.

Development SAR4s (ESAs) are calculated in Table 30.

Table 30: Example #2 – Development generated SAR4s (ESAs)

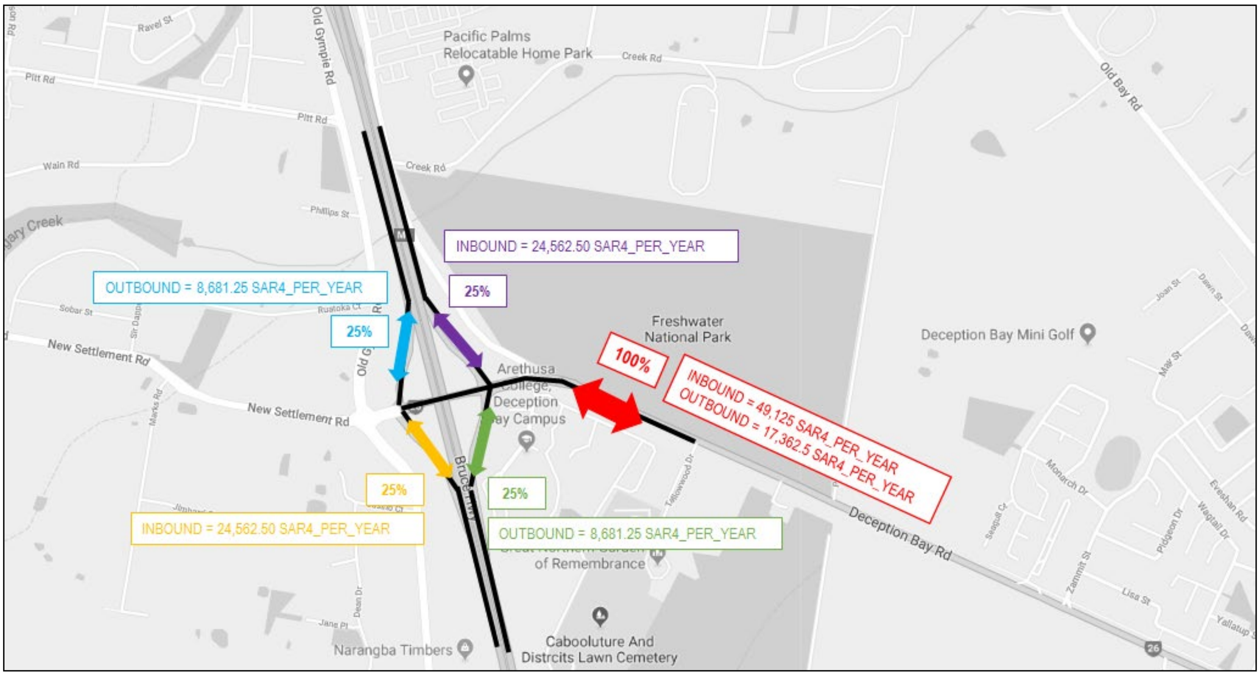
Vehicle class	Loaded				Unloaded				TOTAL_YEAR
	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	
Class 4	25	3.57	89.25	26,775	25	0.50	12.50	3,750	30,525
Class 10	50	6.30	315.00	94,500	50	0.53	26.50	7,950	102,450
TOTAL	75	-	404.25	121,275	75	-	39.00	11,700	132,975

Step 5: Assign development SAR4s (ESAs) onto the SCR network

Relevant details regarding network distribution for Example #2 are summarised below:

- 50% to / from north, via Bruce Highway and Deception Bay Road
- 50% to / from south, via Bruce Highway and Deception Bay Road.

Figure 11 shows development distribution.



Map data: Google, 2018.

Figure 11: Example #2 – Development distribution

Development traffic distribution during the year of opening (2020) is calculated in Table 31.

Table 31: Example #2 – Development traffic distribution

Road data					Development volumes			
Road name	Direction	TDIST_START	TDIST_END	SAR4_PER_YEAR_2020	% distribution	Load status class 4	Load status class 10	SAR4_PER_YEAR_2020
Deception Bay Road	Eastbound	0.13	0.40	713,575	25%	Unloaded	Loaded	24,562.50
	Westbound	0.40	0.13	713,575	25%	Loaded	Unloaded	8,681.25
	Eastbound	0.40	0.55	825,265	50%	Unloaded	Loaded	49,125.00
	Westbound	0.55	0.40	825,265	50%	Loaded	Unloaded	17,362.50
	Eastbound	0.55	1.64	721,605	50%	Unloaded	Loaded	49,125.00
	Westbound	1.64	0.55	721,605	50%	Loaded	Unloaded	17,362.50
Bruce Highway	Northbound	9.73	13.50	4,792,815	25%	Unloaded	Loaded	24,562.50
	Southbound	13.50	9.73	4,792,815	25%	Loaded	Unloaded	8,681.25
	Northbound	13.50	17.96	6,674,025	25%	Loaded	Unloaded	24,562.50
	Southbound	17.96	13.50	6,674,025	25%	Unloaded	Loaded	8,681.25
	Southbound off-ramp	0.00	0.50	461,360	25%	Unloaded	Loaded	24,562.50
	Southbound on-ramp	0.00	0.50	807,745	25%	Loaded	Unloaded	8,681.25
	Northbound off-ramp	0.00	0.50	807,745	25%	Unloaded	Loaded	24,562.50
	Northbound on-ramp	0.00	0.50	461,360	25%	Loaded	Unloaded	8,681.25

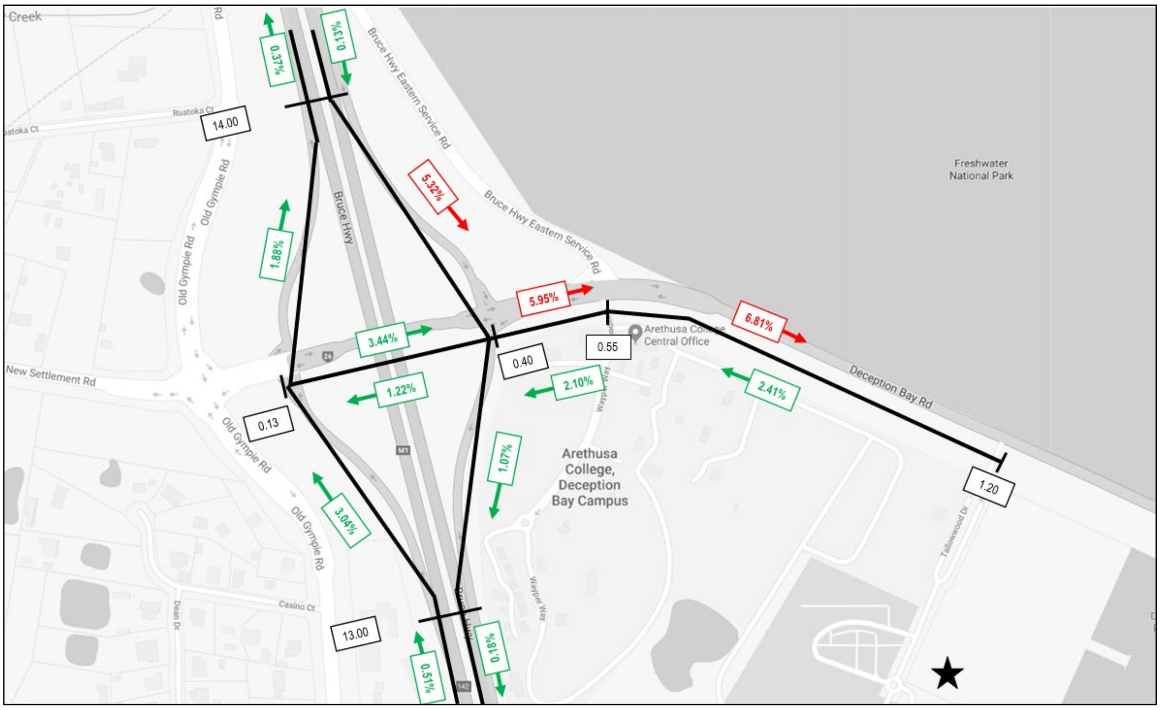
Step 6: Identify road links with >5% development SAR4 (ESAs) impact

Road links with significant (>5%) impacts during the year of opening (2020) are determined in Table 32.

Table 32: Example #2 – Road link impacts

Road name	Direction	TDIST_START	TDIST_END	Background SAR4_PER_YEAR_2020	Development SAR4_PER_YEAR_2020	Development impacts (%)	5% impacts
Deception Bay Road	Eastbound	0.13	0.40	713,575	24,562.50	3.44%	No
	Westbound	0.40	0.13	713,575	8,681.25	1.22%	No
	Eastbound	0.40	0.55	825,265	49,125.00	5.95%	Yes
	Westbound	0.55	0.40	825,265	17,362.50	2.10%	No
	Eastbound	0.55	1.64	721,605	49,125.00	6.81%	Yes
	Westbound	1.64	0.55	721,605	17,362.50	2.41%	No
Bruce Highway	Northbound	9.73	13.50	4,792,815	24,562.50	0.51%	No
	Southbound	13.50	9.73	4,792,815	8,681.25	0.18%	No
	Northbound	13.50	17.96	6,674,025	24,562.50	0.37%	No
	Southbound	17.96	13.50	6,674,025	8,681.25	0.13%	No
	Southbound off-ramp	0.00	0.50	461,360	24,562.50	5.32%	Yes
	Southbound on-ramp	0.00	0.50	807,745	8,681.25	1.07%	No
	Northbound off-ramp	0.00	0.50	807,745	24,562.50	3.04%	No
	Northbound on-ramp	0.00	0.50	461,360	8,681.25	1.88%	No

Figure 12 shows development impacts. Three (3) road links have been identified where development volumes will have significant impacts (i.e. >5%).



Map data: Google, 2018.

Figure 12: Example #2 – Development impacts

Step 7: Calculate contribution to offset development impacts

Relevant details for each impact road segment are provided in Table 33.

Table 33: Example #2 – Road asset data provided by TMR

Segment ID	Road name	SECTION_ID	Carriageway	TDIST_START	TDIST_END	Length	Pavement type	Marginal cost
01	Deception Bay Road	121	2	0.40	0.50	0.10	AC	2.04
02			2	0.50	0.60	0.10	AC	2.04
03			2	0.60	0.7	0.10	AC	2.44
04			2	0.70	0.71	0.01	AC	2.44
05			1	0.71	0.80	0.09	AC	2.44
06			1	0.80	0.90	0.10	AC	2.44
07			1	0.90	1.00	0.10	AC	2.44
08			1	1.00	1.10	0.10	AC	2.44
09			1	1.10	1.20	0.10	AC	2.44
10	Bruce Highway [1]	Southbound off-ramp		0.00	0.50	0.50	CS	10.90

<u>Note 1:</u> Pavement details for ramps are not included in the TMR dataset. Data for the adjacent road section of the Bruce Highway (i.e. Carriageway 3 | TDIST 13.50-14.00) was used for the SB Off-Ramp.

Contribution calculations for Example #2 are shown in Table 34. In summary, for Example #2 the development is required to contribute $8,064.94 per year of operation, to offset development impacts.

Table 34: Example #2 – Contribution calculations

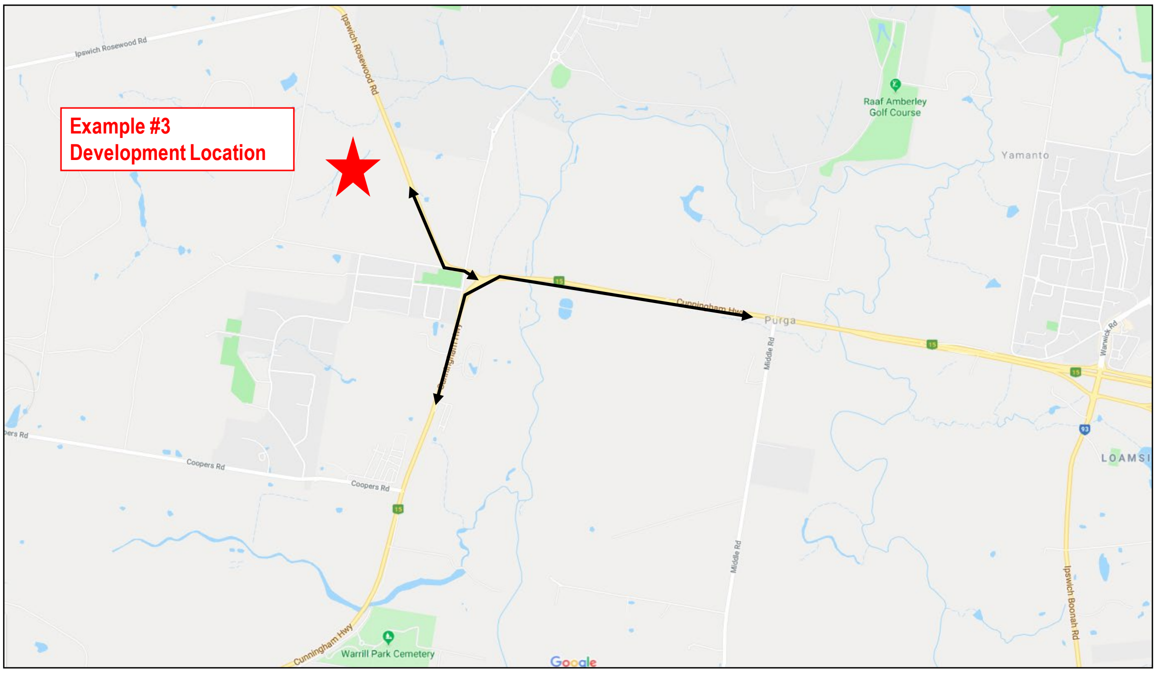
Road data							Class 4 data			Class 10 data			Total	
SECTION_ID	Direction	Section	Length (km)	Pavement type	Load damage exponent	Marginal cost (CENTS_PER_SAR-km)	VOLUMES_PER_YEAR	SAR_PER_TRIP (UNLOADED))	SAR_PER_YEAR	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_YEAR	SAR_PER_YEAR	Development contribution ($)
01	Eastbound	0.40 – 0.50	0.10	AC	5	2.04	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$111.61
02	Eastbound	0.50 – 0.60	0.10	AC	5	2.04	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$111.61
03	Eastbound	0.60 – 0.70	0.10	AC	5	2.44	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$133.50
04	Eastbound	0.70 – 0.71	0.01	AC	5	2.44	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$13.35
05	Eastbound	0.71 – 0.80	0.09	AC	5	2.44	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$120.15
06	Eastbound	0.80 – 0.90	0.10	AC	5	2.44	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$133.50
07	Eastbound	0.90 – 1.00	0.10	AC	5	2.44	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$133.50
08	Eastbound	1.00 – 1.10	0.10	AC	5	2.44	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$133.50
09	Eastbound	1.10 – 1.20	0.10	AC	5	2.44	3,750	0.41	1,538	7,500	7.09	53,175	54,713	$133.50
10	Southbound	0.00 – 0.50	0.50	CS	12	10.90	3,750	0.11	413	7,500	17.17	128,775	129,188	$7,040.72
TOTAL			**1.3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**$8,064.94**

5.3 Example #3: Major development on fringe of urban area (sealed pavement)

Overview

Relevant details for Example #3 are summarised below:

- **Case study aim:** to demonstrate a scenario where a development generates significant heavy vehicle demands, and a pavement impact assessment is triggered (i.e. >5% background SAR4s / ESAs)
- **Development type:** Feedlot
- **Development yield:** 200,000 tonnes per year for 20 years (opening 2020)
- **Location:** Ipswich Rosewood Road, Amberley (access to 304 – Ipswich – Rosewood Road).



Map data: Google, 2018.

Figure 13: Example #3 – Site location overview

Step 1: Impact potential assessment area

Relevant details regarding the development generated traffic for Example #3 are summarised below:

- **Traffic generation:** development will generate:
  - 135 Semi-Trailer (Class 9) vehicles per day (i.e. 270 trips per day)
  - 15 B-Double (Class 10) vehicles per day (i.e. 30 trips per day).
- **Traffic distribution:** development traffic will be 90% to/from the Cunningham Highway (east) and 10% to/from the Cunningham Highway (south)
- **Traffic routes:** development traffic will use Ipswich Rosewood Road to access the Cunningham Highway (east and south).

Based on the above, the potential impact assessment area is defined as:

- Ipswich-Rosewood Road | Road ID: 304 | TDIST: 0.00-1.00

- Cunningham Highway (Ipswich-Warwick Road) | Road ID: 17B | TDIST: 13.73-32.85.

Step 2: Source road asset data from TMR

Road asset data is sourced from TMR for the above study area. Table 35 presents relevant data.

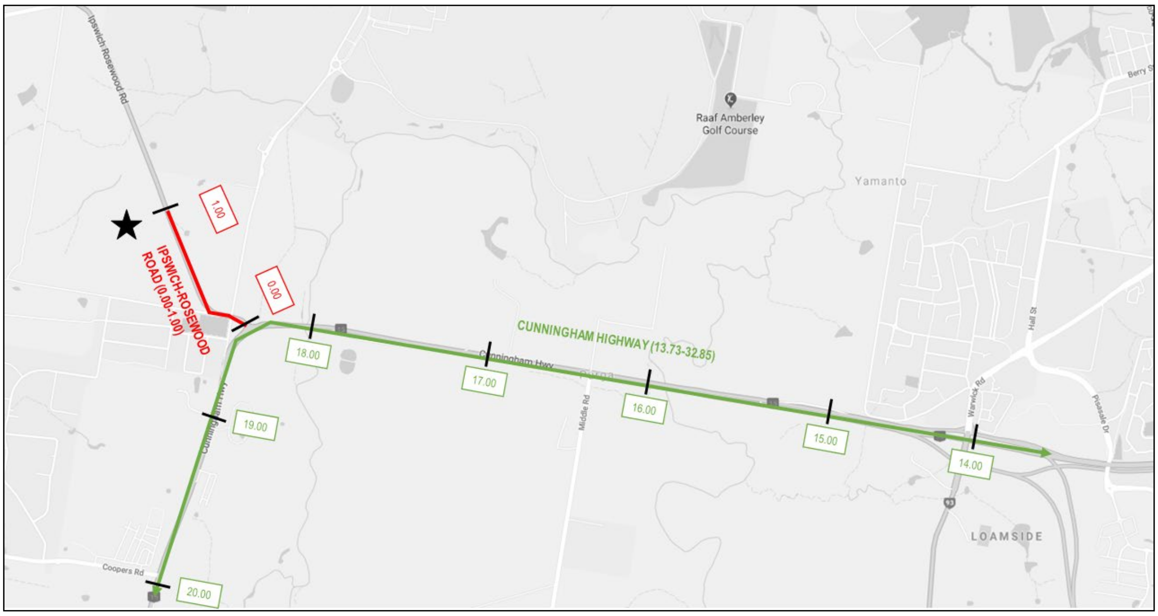
Table 35: Example #3 – Road asset data provided by TMR

Road name	SECTION_ID	TDIST_START	TDIST_END	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV	SAR4_PER_HV
Ipswich-Rosewood Road	304	0.00	3.00	7,711	2017	84.35	15.65	6,504	1,207	3.2
Cunningham Highway	17B	13.73	14.08	20,110	2017	83.53	16.47	16,798	3,312	3.2
		14.08	18.38	20,821	2017	87.71	12.29	18,262	2,559	3.2
		18.38	32.85	6,829	2017	78.97	21.03	5,393	1,436	3.2

Growth rate data was not provided, therefore a 3% annual (linear) growth rate has been adopted. A heavy vehicle directional split of 50% in each direction has been adopted.

Step 3: Calculate background SAR4s (ESAs)

Figure 14 shows the relevant roads and chainage.



Map data: Google, 2018.

Figure 14: Example #3 – Key roads

Background SAR4s are calculated in Table 36.

Table 36: Example #3 – Background SAR4s (ESAs)

Road name	Direction	TDIST_START	TDIST_END	AADT	% HV	AADT_HV	Directionality	SAR4_PER_HV	SAR4_PER_DAY_2017	SAR4_PER_DAY _2020	SAR4_PER_YEAR_2020
Ipswich-Rosewood Road	Northbound	0.00	3.00	7,711	15.65	1,207	50%	3.2	1,931	2,105	768,325
	Southbound	3.00	0.00				50%	3.2	1,931	2,105	768,325
Cunningham Highway	Westbound	13.73	14.08	20,110	16.47	3,312	50%	3.2	5,299	5,776	2,108,240
	Eastbound	14.08	13.73				50%	3.2	5,299	5,776	2,108,240
	Westbound	14.08	18.38	20,821	12.29	2,559	50%	3.2	4,094	4,462	1,628,630
	Eastbound	18.38	14.08				50%	3.2	4,094	4,462	1,628,630
	Southbound	18.38	32.85	6,829	21.03	1,436	50%	3.2	2,298	2,505	914,325
	Northbound	32.85	18.38				50%	3.2	2,298	2,505	914,325

Step 4: Calculate development SAR4s (ESAs)

Relevant details regarding the development SAR4s (ESAs) for Example #3 are summarised below:

- **Vehicle type:** 10% Class 10 (B-Double) and 90% Class 9 (Semi-Trailer)
- **Heavy vehicle traffic volumes:**
  - 270 Class 9 (Semi-Trailer) trips per day (135 inbound + 135 outbound)
  - 30 Class 10 (B-Double) trips per day (15 inbound + 15 outbound).
- **Days of operation:** 300 per year
- **Vehicle loading:**
  - Class 9 (Semi-Trailer): Inbound = 100% unloaded, Outbound = 100% loaded
  - Class 10 (B-Double): Inbound = 100% loaded, Outbound = 100% unloaded.

Development SAR4s are calculated in Table 37.

Table 37: Example #3 – Development generated SAR4s (ESAs)

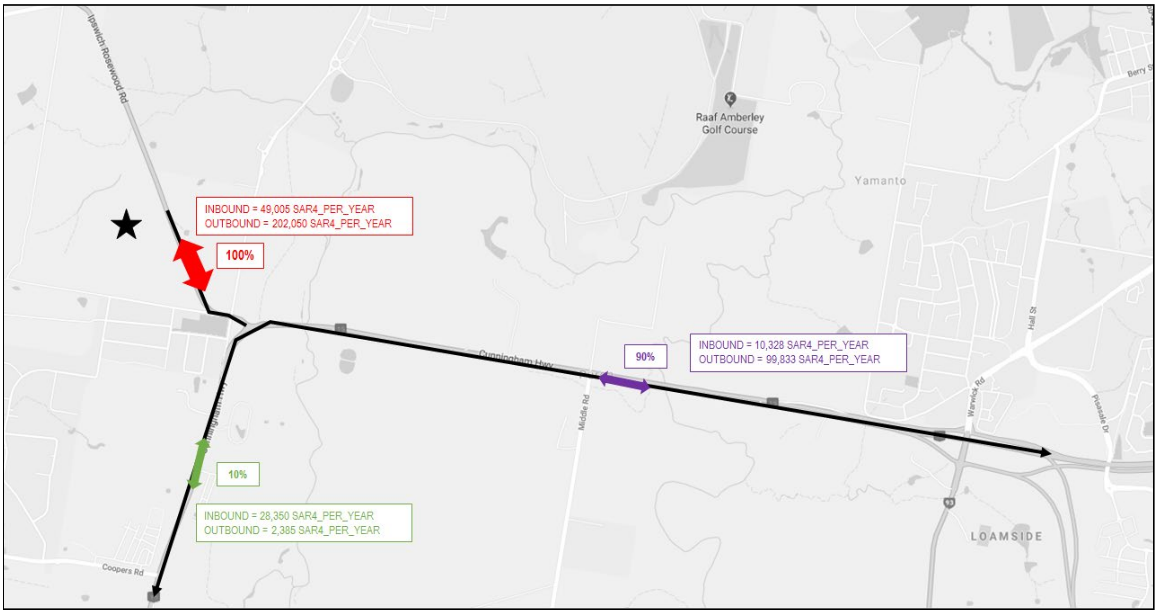
Vehicle class	Loaded				Unloaded				TOTAL_YEAR
	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	
Class 9	135	4.93	665.55	199,665	135	0.51	68.85	20,655	220,320
Class 10	15	6.30	94.5	28,350	15	0.53	7.95	2,385	30,735
TOTAL	150	-	760.05	228,015	150	-	76.8	23,040	251,055

Step 5: Assign development SAR4s (ESAs) onto the SCR network

Relevant details regarding network distribution for Example #3 are summarised below:

- 90% to / from east, via Cunningham Highway (east) – 100% Class 9 vehicles
- 10% to / from south, via Cunningham Highway (south) – 100% Class 10 vehicles.

Figure 15 shows development distribution.



Map data: Google, 2018.

Figure 15: Example #3 – Development distribution

Development traffic distribution during the year of opening (2020) is calculated in Table 38.

Table 38: Example #3 – Development traffic distribution

Road data					Development volumes			
Road name	Direction	TDIST_START	TDIST_END	SAR4_PER_YEAR_2020	% distribution	Load status class 9	Load status class 10	SAR4_PER_YEAR_2020
Ipswich-Rosewood Road	Northbound	0.00	3.00	768,325	50%	Unloaded	Loaded	49,005
	Southbound	3.00	0.00	768,325	50%	Loaded	Unloaded	202,050
Cunningham Highway	Westbound	13.73	14.08	2,108,240	45%	Unloaded	n/a	10,328
	Eastbound	14.08	13.73	2,108,240	45%	Loaded	n/a	99,833
	Westbound	14.08	18.38	1,628,630	45%	Unloaded	n/a	10,328
	Eastbound	18.38	14.08	1,628,630	45%	Loaded	n/a	99,833
	Southbound	18.38	32.85	914,325	5%	n/a	Unloaded	2,385
	Northbound	32.85	18.38	914,325	5%	n/a	Loaded	28,350

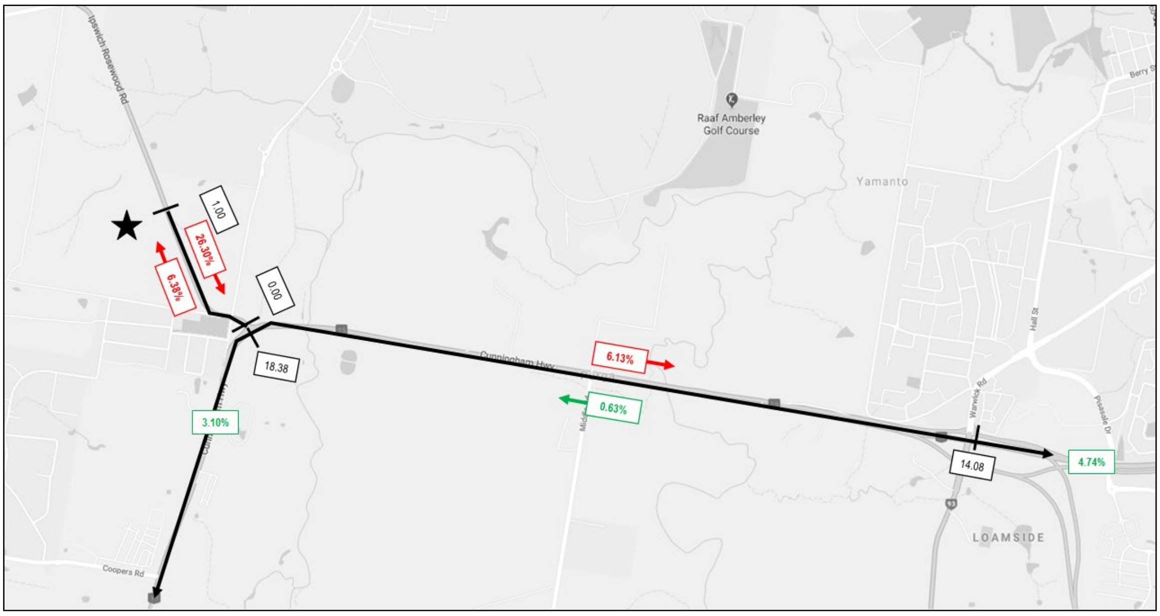
Step 6: Identify road links with >5% development SAR4 (ESAs) impact

Road links with significant (>5%) impacts are determined in Table 39.

Table 39: Example #3 – Road link impacts

Road name	Direction	TDIST_START	TDIST_END	Background SAR4_PER_YEAR_2020	Development SAR4_PER_YEAR_2020	Development impacts (%)	5% impacts
Ipswich-Rosewood Road	Northbound	0.00	3.00	768,325	49,005	6.38%	Yes
	Southbound	3.00	0.00	768,325	202,050	26.30%	Yes
Cunningham Highway	Westbound	13.73	14.08	2,108,240	10,328	0.49%	No
	Eastbound	14.08	13.73	2,108,240	99,833	4.74%	No
	Westbound	14.08	18.38	1,628,630	10,328	0.63%	No
	Eastbound	18.38	14.08	1,628,630	99,833	6.13%	Yes
	Southbound	18.38	32.85	914,325	2,385	0.26%	No
	Northbound	32.85	18.38	914,325	28,350	3.10%	No

Figure 16 shows development impacts during the year of opening (2020). Three (3) road links have been identified where development volumes will have significant impacts (i.e. >5%) during the year of opening (2020).



Map data: Google, 2018.

Figure 16: Example #3 – Development Impacts

Step 7: Calculate contribution to offset development impacts

Relevant details for each impact road segment are provided in Table 40.

Table 40: Example #3 – Road asset data provided by TMR

Segment ID	Road name	SECTION_ID	Carriageway	TDIST_START	TDIST_END	Length	Pavement type	Marginal cost
01	Ipswich-Rosewood Road	304	2	0.00	0.10	0.1	AC	1.79
02			3	0.00	0.10	0.1	AC	1.79
03			2	0.10	0.17	0.07	AC	7.64
04			3	0.10	0.17	0.07	AC	7.64
05			1	0.17	0.20	0.03	AC	7.64
07			1	0.20	0.30	0.1	AC	7.46
08			1	0.30	0.40	0.01	AC	7.50
09			1	0.40	0.50	0.09	AC	7.76
10			1	0.50	0.60	0.1	AC	8.24
11			1	0.60	0.70	0.1	AC	8.09
12			1	0.70	0.80	0.1	AC	8.13
13			1	0.80	0.90	0.1	AC	7.75
14			1	0.90	1.00	0.1	AC	7.75
15	Cunningham Highway	17B	1	14.00	14.10	0.1	AC	2.47
16			1	14.10	14.20	0.1	AC	2.97
17			1	14.20	14.22	0.02	AC	2.33
18			3	14.22	14.30	0.08	AC	3.43
19			3	14.30	14.40	0.1	AC	3.43
20			3	14.40	14.50	0.1	AC	3.43
21			3	14.50	14.60	0.1	AC	3.43
22			3	14.60	14.70	0.1	AC	3.43
23			3	14.70	14.80	0.1	AC	3.43
24			3	14.80	14.90	0.1	AC	3.43
25			3	14.90	15.00	0.1	AC	3.43
26			3	15.00	15.10	0.1	AC	3.43
27			3	15.10	15.20	0.1	AC	3.43
28			3	15.20	15.30	0.1	AC	3.43
29			3	15.30	15.40	0.1	AC	3.43
30			3	15.40	15.50	0.1	AC	3.43
31			3	15.50	15.60	0.1	CS	1.39
32			3	15.60	15.70	0.1	CS	1.39
33			1	15.70	15.80	0.1	CS	1.36
34			1	15.80	15.90	0.1	CS	1.59
35			1	15.90	16.00	0.1	CS	1.38
36			1	16.00	16.10	0.1	CS	1.33

Segment ID	Road name	SECTION_ID	Carriageway	TDIST_START	TDIST_END	Length	Pavement type	Marginal cost
37			1	16.10	16.20	0.1	CS	1.34
38			1	16.20	16.30	0.1	CS	1.43
39			1	16.30	16.40	0.1	CS	1.60
40			1	16.40	16.50	0.1	CS	1.33
41			1	16.50	16.60	0.1	CS	1.28
42			1	16.60	16.70	0.1	CS	1.34
43			1	16.70	16.80	0.1	CS	1.33
44			1	16.80	16.90	0.1	CS	1.27
45			1	16.90	17.00	0.1	CS	1.21
46			1	17.00	17.10	0.1	CS	1.53
47			1	17.10	17.20	0.1	CS	1.59
48			1	17.20	17.30	0.1	CS	1.33
49			1	17.30	17.40	0.1	CS	1.33
50			1	17.40	17.50	0.1	CS	1.33
51			1	17.50	17.60	0.1	CS	1.33
52			1	17.60	17.70	0.1	CS	1.33
53			1	17.70	17.80	0.1	CS	1.33
54			1	17.80	17.90	0.1	CS	1.34
55			1	17.90	18.00	0.1	CS	1.33
56			1	18.00	18.10	0.1	CS	1.20
57			1	18.10	18.20	0.1	AC	2.83
58			1	18.20	18.23	0.03	AC	2.87
59			3	18.23	18.30	0.07	AC	3.43
60			3	18.30	18.40	0.1	AC	3.43

Contribution calculations for Example #3 are shown in Table 41

In summary, for Example #3 the development is required to contribute $54,276.01 per year of operation, to offset development impacts.

Table 41: Example #3 – Contribution calculations

Road data							Class 9 data				Class 10 data				Total	
SECTION_ID	Direction	Section	Length (km)	Pavement type	Load damage exponent	Marginal cost (CENTS_PER_SAR-km)	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_TRIP (UNLOADED))	SAR_PER_YEAR	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_TRIP (UNLOADED))	SAR_PER_YEAR	SAR_PER_YEAR	Development contribution ($)
01	Northbound	0.00-0.10	0.10	AC	5	1.79	40,500		0.41	16,605	4,500	7.09		31,905	48,510	$86.83
02	Southbound	0.00-0.10	0.10	AC	5	1.79	40,500	5.61		227,205	4,500		0.42	1,890	229,095	$410.08
03	Northbound	0.10-0.17	0.07	AC	5	7.64	40,500		0.41	16,605	4,500	7.09		31,905	48,510	$259.43
04	Southbound	0.10-0.17	0.07	AC	5	7.64	40,500	5.61		227,205	4,500		0.42	1,890	229,095	$1,225.20
05	Both	0.17-0.20	0.03	AC	5	7.64	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$636.27
06	Both	0.20-0.30	0.10	AC	5	7.46	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,070.93
07	Both	0.30-0.40	0.10	AC	5	7.5	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,082.04
08	Both	0.40-0.50	0.10	AC	5	7.76	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,154.21
09	Both	0.50-0.60	0.10	AC	5	8.24	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,287.47
10	Both	0.60-0.70	0.10	AC	5	8.09	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,245.82
11	Both	0.70-0.80	0.10	AC	5	8.13	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,256.93
12	Both	0.80-0.90	0.10	AC	5	7.75	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,151.44
13	Both	0.90-1.00	0.10	AC	5	7.75	81,000	5.61	0.41	243,810	9,000	7.09	0.42	33,795	277,605	$2,151.44
14	Eastbound	14.00-14.10	0.10	AC	5	2.47	40,500	5.61		113,603					113,603	$280.60
15	Eastbound	14.10-14.20	0.10	AC	5	2.97	40,500	5.61		227,205					227,205	$674.80
16	Eastbound	14.20-14.22	0.02	AC	5	2.33	40,500	5.61		227,205					227,205	$105.88
17	Eastbound	14.22-14.30	0.08	AC	5	3.43	40,500	5.61		227,205					227,205	$623.45
18	Eastbound	14.30-14.40	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
19	Eastbound	14.40-14.50	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
20	Eastbound	14.50-14.60	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
21	Eastbound	14.60-14.70	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31

Road data							Class 9 data				Class 10 data				Total	
SECTION_ID	Direction	Section	Length (km)	Pavement type	Load damage exponent	Marginal cost (CENTS_PER_SAR-km)	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_TRIP (UNLOADED))	SAR_PER_YEAR	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_TRIP (UNLOADED))	SAR_PER_YEAR	SAR_PER_YEAR	Development contribution ($)
22	Eastbound	14.70-14.80	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
23	Eastbound	14.80-14.90	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
24	Eastbound	14.90-15.00	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
25	Eastbound	15.00-15.10	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
26	Eastbound	15.10-15.20	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
27	Eastbound	15.20-15.30	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
28	Eastbound	15.30-15.40	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
29	Eastbound	15.40-15.50	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
30	Eastbound	15.50-15.60	0.10	CS	12	1.39	40,500	14.63		592,515					592,515	$823.60
31	Eastbound	15.60-15.70	0.10	CS	12	1.39	40,500	14.63		592,515					592,515	$823.60
32	Eastbound	15.70-15.80	0.10	CS	12	1.36	40,500	14.63		592,515					592,515	$805.82
33	Eastbound	15.80-15.90	0.10	CS	12	1.59	40,500	14.63		592,515					592,515	$942.10
34	Eastbound	15.90-16.00	0.10	CS	12	1.38	40,500	14.63		592,515					592,515	$817.67
35	Eastbound	16.00-16.10	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
36	Eastbound	16.10-16.20	0.10	CS	12	1.34	40,500	14.63		592,515					592,515	$793.97
37	Eastbound	16.20-16.30	0.10	CS	12	1.43	40,500	14.63		592,515					592,515	$847.30
38	Eastbound	16.30-16.40	0.10	CS	12	1.6	40,500	14.63		592,515					592,515	$948.02
39	Eastbound	16.40-16.50	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
40	Eastbound	16.50-16.60	0.10	CS	12	1.28	40,500	14.63		592,515					592,515	$758.42
41	Eastbound	16.60-16.70	0.10	CS	12	1.34	40,500	14.63		592,515					592,515	$793.97
42	Eastbound	16.70-16.80	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
43	Eastbound	16.80-16.90	0.10	CS	12	1.27	40,500	14.63		592,515					592,515	$752.49

Road data							Class 9 data				Class 10 data				Total	
SECTION_ID	Direction	Section	Length (km)	Pavement type	Load damage exponent	Marginal cost (CENTS_PER_SAR-km)	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_TRIP (UNLOADED))	SAR_PER_YEAR	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_TRIP (UNLOADED))	SAR_PER_YEAR	SAR_PER_YEAR	Development contribution ($)
44	Eastbound	16.90-17.00	0.10	CS	12	1.21	40,500	14.63		592,515					592,515	$716.94
45	Eastbound	17.00-17.10	0.10	CS	12	1.53	40,500	14.63		592,515					592,515	$906.55
46	Eastbound	17.10-17.20	0.10	CS	12	1.59	40,500	14.63		592,515					592,515	$942.10
47	Eastbound	17.20-17.30	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
48	Eastbound	17.30-17.40	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
49	Eastbound	17.40-17.50	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
50	Eastbound	17.50-17.60	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
51	Eastbound	17.60-17.70	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
52	Eastbound	17.70-17.80	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
53	Eastbound	17.80-17.90	0.10	CS	12	1.34	40,500	14.63		592,515					592,515	$793.97
54	Eastbound	17.90-18.00	0.10	CS	12	1.33	40,500	14.63		592,515					592,515	$788.04
55	Eastbound	18.00-18.10	0.10	CS	12	1.2	40,500	14.63		592,515					592,515	$711.02
56	Eastbound	18.10-18.20	0.10	AC	5	2.83	40,500	5.61		227,205					227,205	$642.99
57	Eastbound	18.20-18.23	0.03	AC	5	2.87	40,500	5.61		227,205					227,205	$195.62
58	Eastbound	18.23-18.30	0.07	AC	5	3.43	40,500	5.61		227,205					227,205	$545.52
59	Eastbound	18.30-18.40	0.10	AC	5	3.43	40,500	5.61		227,205					227,205	$779.31
TOTAL			**5.57**	-	-	-	-	-	-	-	-	-	-	-	-	**$54,276.01**

5.4 Example #4: Major development in rural area (sealed pavement)

Overview

Relevant details for Example #4 are summarised below:

- **Case study aim:** to demonstrate a scenario where a development generates significant heavy vehicle demands, and a pavement impact assessment is triggered (i.e. >5% background SAR4s / ESAs)
- **Development type:** Quarry
- **Development yield:** 250,000 tonnes per year for 30 years (opening 2022)
- **Potential Location:** Peak Downs Highway, Moranbah (access to 33A – CLERMONT_NEBO).

Note this case study aligns with Case Study 3 of the GTIA.

Map data: Google, 2018.

Figure 17: Example #4 – Site location overview

Step 1: Impact potential assessment area

Relevant details regarding the development generated traffic for Example #4 are summarised below:

- **Traffic generation:** development will generate: 30 Semi-Trailer (Class 9) vehicles per day (i.e. 60 trips per day)
- **Traffic distribution:** development traffic will be 100% to/from the north
- **Traffic routes:** development traffic will use the Peak Downs Highway for access

Based on the above, the potential impact assessment area is defined as:

- Peak Downs Highway (Clermont – Nebo) | Road ID: 33A | TDIST: 88.50-101.77.

Step 2: Source road asset data from TMR

Road asset data is sourced from TMR for the above study area. Table 42 presents relevant data.

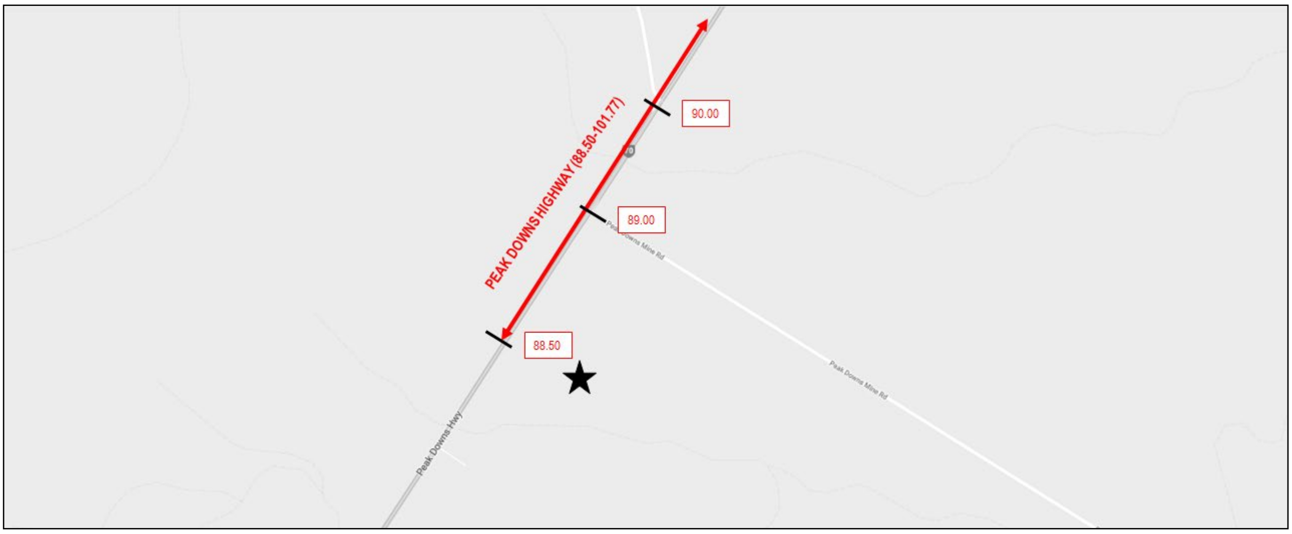
Table 42: Example #4 – Road asset data provided by TMR

Road name	SECTION_ID	TDIST_START	TDIST_END	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV	SAR4_PER_HV
Peak Downs Highway	33A	0.00	89.05	574	2017	71.44	28.56	4,10	164	3.2
		89.05	90.37	3,014	2017	81.85	18.15	2,467	547	3.2
		90.37	101.77	2,870	2017	69.35	30.65	1,990	880	3.2

Growth rate data was not provided, therefore a 3% annual (linear) growth rate has been adopted. A heavy vehicle directional split of 50% in each direction has been adopted.

Step 3: Calculate background SAR4s (ESAs)

Figure 18 shows the relevant roads and chainage.



Map data: Google, 2018.

Figure 18: Example #4 – Key roads

Background SAR4s (ESAs) are calculated in Table 43.

Table 43: Example #4 - Background SAR4s (ESAs)

Road name	Direction	TDIST_START	TDIST_END	AADT	% HV	AADT_HV	Directionality	SAR4_PER_HV	SAR4_PER_DAY_2017	SAR4_PER_DAY_2020	SAR4_PER_YEAR_2020
Peak Downs Highway	Northbound	0.00	89.05	574	28.56	164	50%	3.2	262	301	109,865
	Southbound	89.05	0.00				50%	3.2	262	301	109,865
	Northbound	89.05	90.37	3,014	18.15	547	50%	3.2	875	1,006	367,190
	Southbound	90.37	89.05				50%	3.2	875	1,006	367,190
	Northbound	90.37	101.77	101.77	30.65	880	50%	3.2	1,408	1,619	590,935
	Southbound	101.77	90.37				50%	3.2	1,408	1,619	590,935

Step 4: Calculate development SAR4s

Relevant details regarding the development SAR4s (ESAs) for Example #4 are summarised below:

- **Vehicle type:** 100% Class 9 (Semi-Trailer).
- **Heavy vehicle traffic volumes:** 60 Class 9 (Semi-Trailer) trips per day (30 inbound + 30 outbound)
- **Days of operation:** 250 per year
- **Vehicle loading:** Class 9 (Semi-Trailer): Inbound = 100% unloaded, Outbound = 100% loaded.

Development SAR4s (ESAs) are calculated in Table 44.

Table 44: Example #4 – Development generated SAR4s (ESAs)

Vehicle class	Loaded				Unloaded				TOTAL_YEAR
	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	Daily demand	SAR4_PER_VEHICLE	SAR4_DAY	SAR4_YEAR	
Class 9	30	4.93	147.9	44,370	30	0.51	15.3	4,590	48,960

Step 5: Assign development SAR4s (ESAs) onto the SCR network

Relevant details regarding network distribution for Example #4 are summarised below:

- 100% to / from north, via Peak Downs Highway.

Figure 19 shows development distribution.

Map data: Google, 2018.

Figure 19: Example #4 – Development distribution

As outlined above, all inbound vehicles will be unloaded and all outbound vehicles will be loaded. Development traffic distribution during the year of opening (2022) is calculated in Table 45.

Table 45: Example #4 – Development traffic distribution

Road data					Development volumes		
Road name	Direction	TDIST_START	TDIST_END	SAR4 / YEAR_2022	% distribution	Load status class 9	SAR4 / YEAR_2022
Peak Downs Highway	Northbound	0.00	89.05	109,865	50%	Loaded	22,185.00
	Southbound	89.05	0.00	109,865	50%	Unloaded	2,295.00
	Northbound	89.05	90.37	367,190	50%	Loaded	22,185.00
	Southbound	90.37	89.05	367,190	50%	Unloaded	2,295.00
	Northbound	90.37	101.77	590,935	50%	Loaded	22,185.00
	Southbound	101.77	90.37	590,935	50%	Unloaded	2,295.00

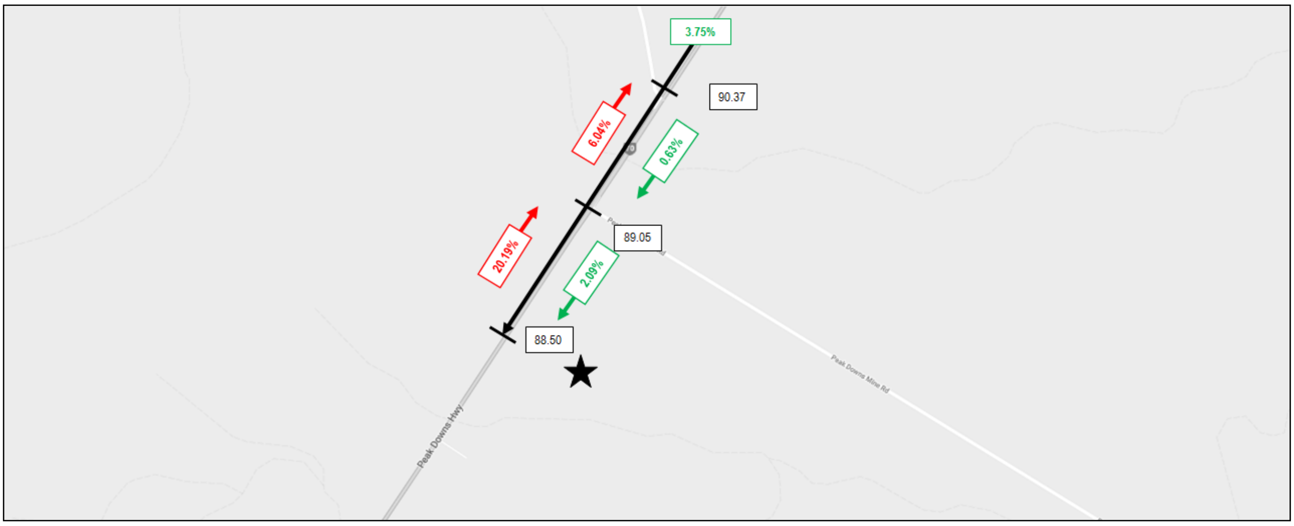
Step 6: Identify road links with >5% development SAR4 (ESAs) impact

Road links with significant (>5%) impacts during the year of opening (2022) are determined in Table 46.

Table 46: Example #4 – Road link impacts

Road name	Direction	TDIST_START	TDIST_END	background SAR4 / YEAR_2022	Development SAR4 / YEAR_2022	Development impacts (%)	>5% impacts
Peak Downs Highway	Northbound	0.00	89.05	109,865	22,185.00	20.19%	Yes
	Southbound	89.05	0.00	109,865	2,295.00	2.09%	No
	Northbound	89.05	90.37	367,190	22,185.00	6.04%	Yes
	Southbound	90.37	89.05	367,190	2,295.00	0.63%	No
	Northbound	90.37	101.77	590,935	22,185.00	3.75%	No
	Southbound	101.77	90.37	590,935	2,295.00	0.39%	No

Figure 20 shows development impacts during the year of opening (2022). Two (2) road links have been identified where development volumes will have significant impacts (i.e. >5%) during the year of opening (2022).



Map data: Google, 2018.

Figure 20: Example #4 – Development impacts

Step 7: Calculate contribution to offset development impacts

Relevant details for each impact road segment are provided in Table 47.

Table 47: Example #4 – Road asset data provided by TMR

Segment ID	Road name	SECTION_ID	Carriageway	TDIST_START	TDIST_END	Length	Pavement type	Marginal cost
1	Peak Downs Highway	33A	1	88.5	88.6	0.10	CS	3.17
2			1	88.6	88.7	0.10	CS	3.17
3			1	88.7	88.8	0.10	CS	3.17
4			1	88.8	88.9	0.10	CS	3.17
5			1	88.9	89.0	0.10	CS	3.24
6			1	89.0	89.1	0.10	CS	3.24
7			1	89.1	89.2	0.10	CS	3.24
8			1	89.2	89.3	0.10	CS	3.24
9			1	89.3	89.4	0.10	CS	3.24
10			1	89.4	89.5	0.10	CS	2.87
11			1	89.5	89.6	0.10	CS	1.92
12			1	89.6	89.7	0.10	CS	1.92
13			1	89.7	89.8	0.10	CS	1.92
14			1	89.8	89.9	0.10	CS	1.92
15			1	89.9	90.0	0.10	CS	1.92
16			1	90.0	90.1	0.10	CS	1.92
17			1	90.1	90.2	0.10	CS	1.92
18			1	90.2	90.3	0.10	AC	1.92
19			1	90.3	90.4	0.10	AC	1.92

Contribution calculations for Example #4 are shown in Table 48.

In summary, for Example #4 the development is required to contribute $1,812.88 per year of operation, to offset development impacts.

Table 48: Example #4 – Contribution calculations

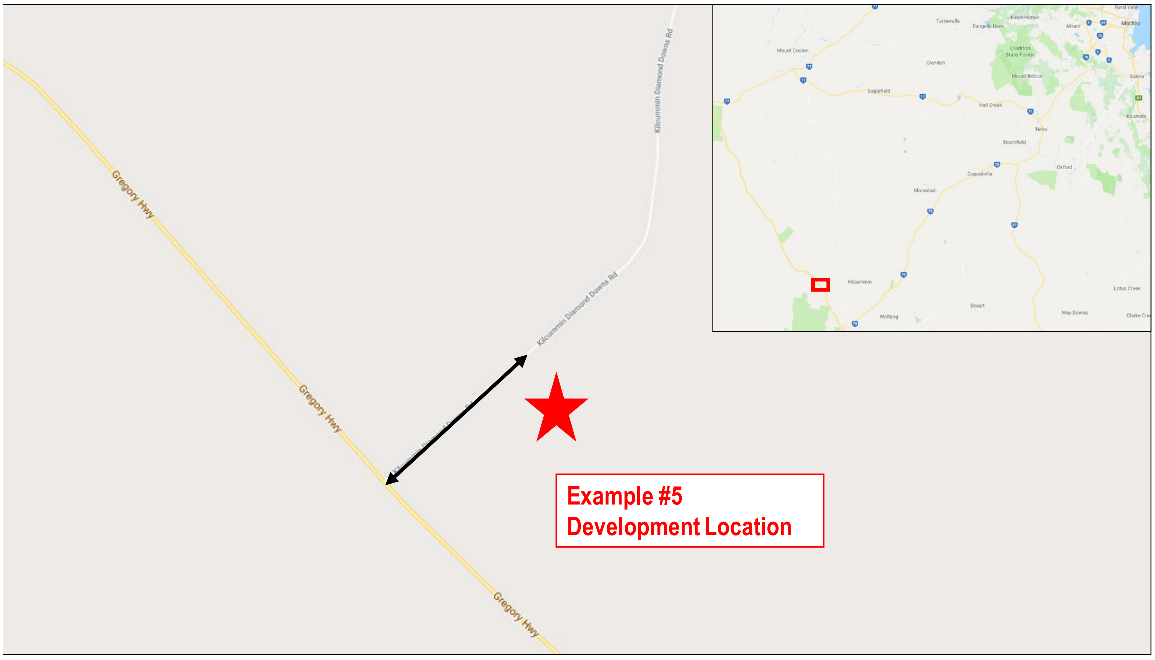
Road data							Class 9 data		Total	
SECTION_ID	Direction	Section	length (km)	Pavement type	Load damage exponent	Marginal cost (CENTS/SAR-km)	VOLUMES_PER_YEAR	SAR_PER_TRIP (LOADED))	SAR_PER_YEAR	Development contributions ($)
01	Northbound	88.50-88.60	0.10	CS	12	3.17	7,500	14.63	109,725	$347.83
02	Northbound	88.60-88.70	0.10	CS	12	3.17	7,500	14.63	109,725	$347.83
03	Northbound	88.70-88.80	0.10	CS	12	3.17	7,500	14.63	109,725	$347.83
04	Northbound	88.80-88.90	0.10	CS	12	3.17	7,500	14.63	109,725	$347.83
05	Northbound	88.90-89.00	0.10	CS	12	3.24	7,500	14.63	109,725	$355.51
06	Northbound	89.00-89.10	0.10	CS	12	3.24	7,500	14.63	109,725	$355.51
07	Northbound	89.10-89.20	0.10	CS	12	3.24	7,500	14.63	109,725	$355.51
08	Northbound	89.20-89.30	0.10	CS	12	3.24	7,500	14.63	109,725	$355.51
09	Northbound	89.30-89.40	0.10	CS	12	3.24	7,500	14.63	109,725	$355.51
10	Northbound	89.40-89.50	0.10	CS	12	2.87	7,500	14.63	109,725	$314.91
11	Northbound	89.50-89.60	0.10	CS	12	1.92	7,500	14.63	109,725	$210.67
12	Northbound	89.60-89.70	0.10	CS	12	1.92	7,500	14.63	109,725	$210.67
13	Northbound	89.70-89.80	0.10	CS	12	1.92	7,500	14.63	109,725	$210.67
14	Northbound	89.80-89.90	0.10	CS	12	1.92	7,500	14.63	109,725	$210.67
15	Northbound	89.90-90.00	0.10	CS	12	1.92	7,500	14.63	109,725	$210.67
16	Northbound	90.00-90.10	0.10	CS	12	1.92	7,500	14.63	109,725	$210.67
17	Northbound	90.10-90.20	0.10	CS	12	1.92	7,500	14.63	109,725	$210.67
18	Northbound	90.20-90.30	0.10	AC	5	1.92	7,500	5.61	42,075	$80.78
19	Northbound	90.30-90.40	0.10	AC	5	1.92	7,500	5.61	42,075	$80.78
Total			**1.9**	**-**	**-**	**-**	**-**	**-**		**$5,120.04**

5.5 Example #5: Development near an unsealed road

Overview

Relevant details for Example #5 are summarised below:

- **Case study aim:** to demonstrate a scenario where a development generates HV traffic, and a pavement impact assessment is triggered (i.e. >5% background LUs)
- **Development type:** Quarry
- **Development yield:** 250,000 tonnes per year for 30 years (opening 2022)
- **Potential Location:** Kilcummin Diamond Downs Road, Kilcummin (access to Kilcummin - Diamond Downs Road).



Map data: Google, 2018.

Figure 21: Example #5 – Site location overview

Step 1: Impact potential assessment area

Relevant details regarding the development generated traffic for Example #5 are summarised below:

- **Traffic generation:** development will generate: 30 Semi-Trailer (Class 9) vehicles per day (i.e. 60 trips per day) and 60 Car (Class 1) vehicles per day (i.e. 120 trips)
- **Traffic distribution:** development traffic will be 100% from the Gregory Highway
- **Traffic routes:** development traffic will use the Gregory Highway for access to Kilcummin Diamond Downs Road.

Note: for this scenario, impacts to the Gregory Highway (i.e. sealed network) will not be considered.

Based on the above, the potential impact assessment area is defined as:

- Kilcummin Diamond Downs Road | Road ID: 5309 | TDIST: 0.00-1.00.

Step 2: Source road asset data from TMR

Road asset data is sourced from TMR for the above study area. Table 49 presents relevant data.

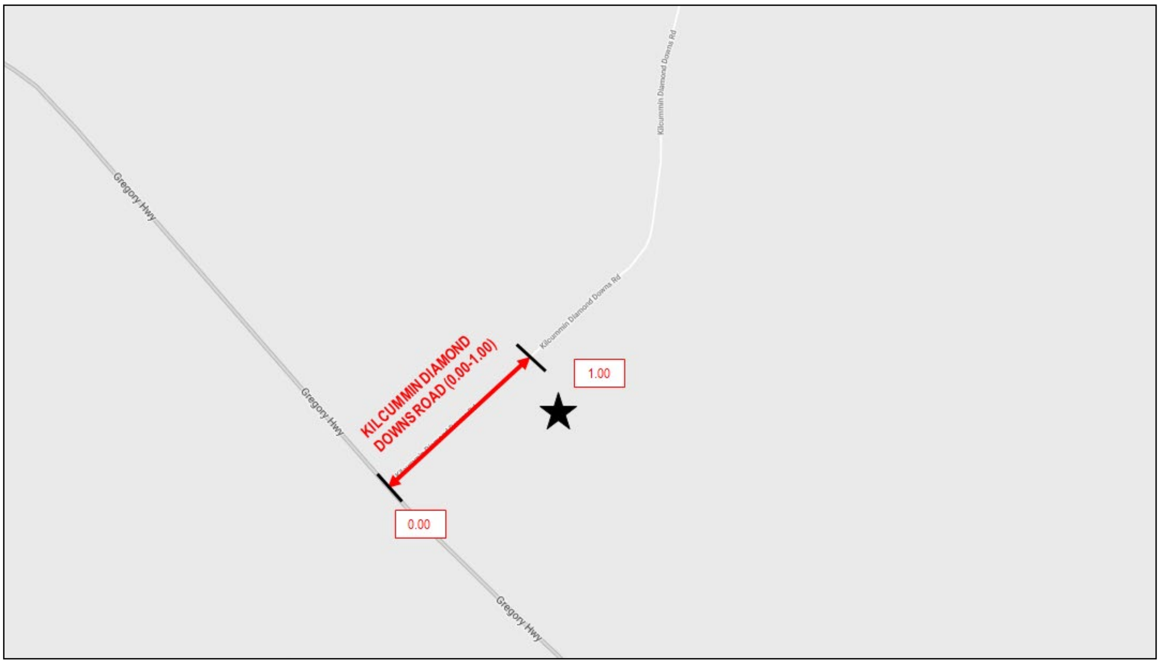
Table 49: Example #5 – Road asset data provided by TMR

Road name	SECTION_ID	TDIST_START	TDIST_END	AADT	AADT_YEAR	%_NONHV	%_HV	AADT_NONHV	AADT_HV	AADT_HV_1A	AADT_HV_1B	AADT_HV_1C	AADT_HV_1D
Kilcummin Diamond Downs Road	5309	0.00	67.74	65	2017	70.67	29.33	46	19	46	11	2	6

Growth rate data was not provided, therefore a 3% annual (linear) growth rate has been adopted. A heavy vehicle directional split of 50% in each direction has been adopted.

Step 3: Calculate background LUs

Figure 22 shows the relevant roads and chainage.



Map data: Google, 2018.

Figure 22 Example #5 – Key roads

Background LUs are calculated in Table 50.

Table 50: Example #5 – Background LUs

Road data				Category 1A			Category 1B			Category 1C			Category 1D			Total		
Road name	SECTION_ID	TDIST_START	TDIST_END	AADT_HV	LU_PER_VEHICLE	LU_PER_DAY	AADT_HV	LU_PER_HV	LU_PER_DAY	AADT_HV	LU_PER_HV	LU_PER_DAY	AADT_HV	LU_PER_HV	L LU_PER_DAY	LU_PER_DAY	LU_PER_YEAR_2017	LU_PER_YEAR_2022
Kilcummin Diamond Downs Road	5309	0	67.74	46	1.0	46.0	11	1.1	12.1	2	2.48	4.96	6	5.25	31.5	94.56	34,514	39,691

Step 4: Calculate development LUs

Relevant details regarding the development generated LUs for Example #5 are summarised below:

- **Vehicle type:** 533% Class 9 (Semi-Trailer) and 67% Class 1 (Car)
- **Light vehicle traffic volumes:** 120 Class 1 (Car) trips per day (60 inbound + 60 outbound)
- **Heavy vehicle traffic volumes:** 60 Class 9 (Semi-Trailer) trips per day (30 inbound + 30 outbound)
- **Days of operation:** 250 per year.

Development LUs are calculated in Table 51.

Table 51: Example #5 – Development generated LUs

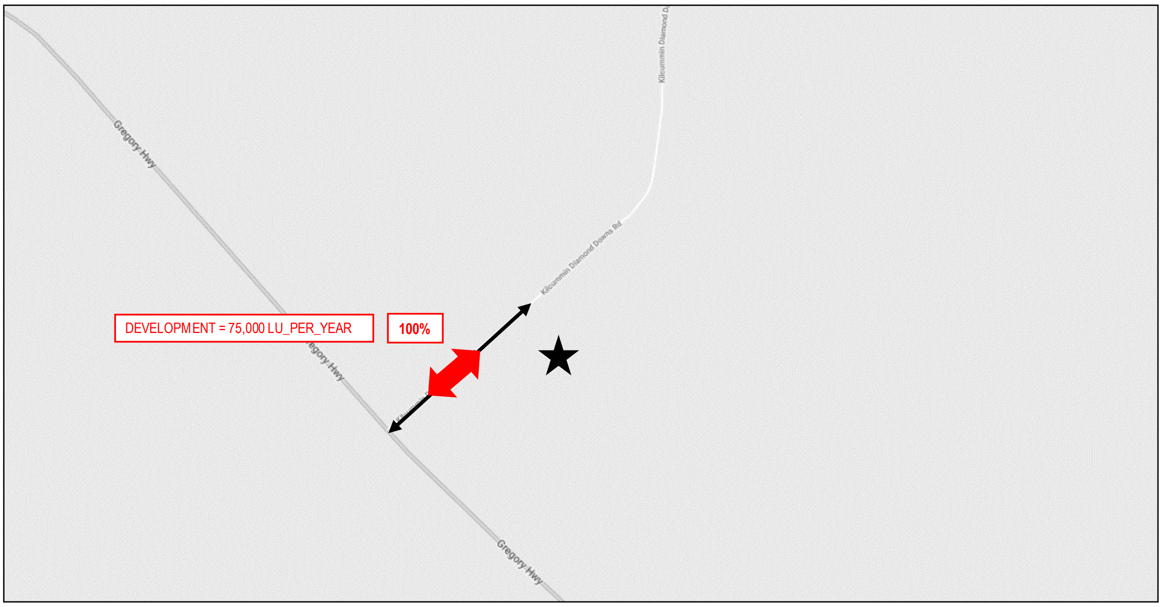
Vehicle class	Daily demand	LU_PER_VEHICLE	LU_PER_DAY	LU_PER_YEAR
Class 1	120	1	120	30,000
Class 9	60	3	180	45,000

Step 5: Assign development LUs onto the SCR network

Relevant details regarding network distribution for Example #5 are summarised below:

- 100% to / from Gregory Highway, via Kilcummin Diamond Downs Road.

Figure 23 shows development distribution.



Map data: Google, 2018.

Figure 23: Example #5 – Development distribution

Development traffic distribution during the year of opening (2022) is calculated in Table 52.

Table 52: Example #5 – Development traffic distribution

Road data				Development volumes	
Road name	TDIST_START	TDIST_END	LU_PER_YEAR_2022	% distribution	LU_PER_YEAR_2022
Kilcummin Diamond Downs Road	0.00	67.74	39,691	100%	75,000

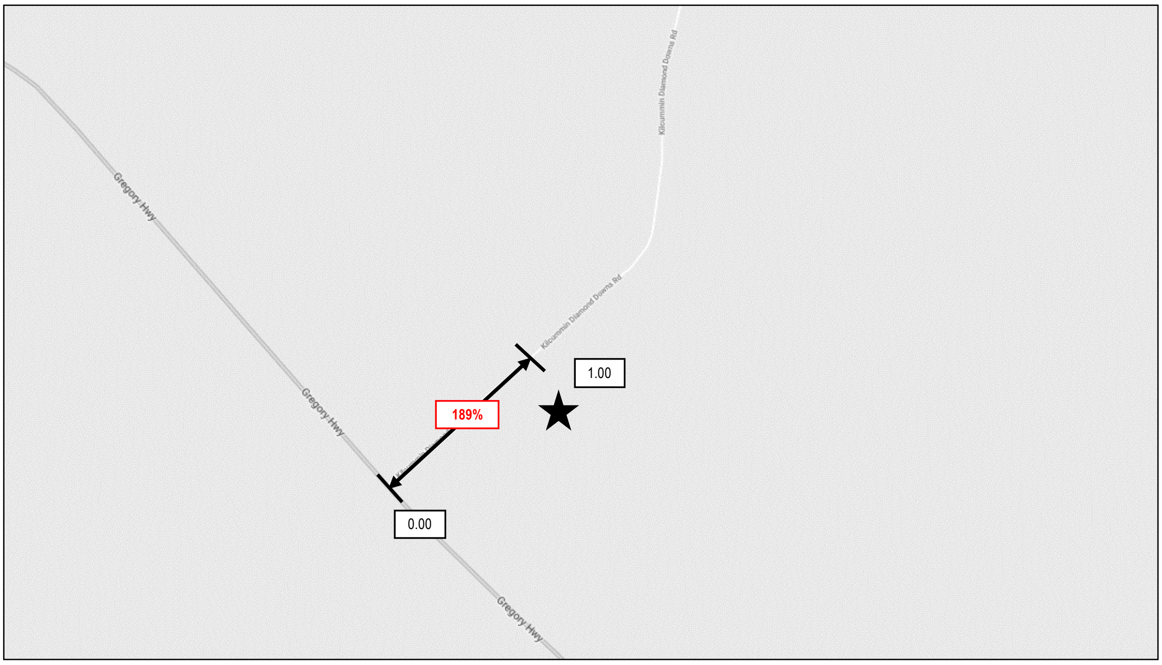
Step 6: Identify road links with >5% development LU impact

Road links with significant (>5%) impacts during the year of opening (2022) are determined in Table 53.

Table 53: Example #5 – Road link impacts

Road name	TDIST_START	TDIST_END	background LU / YEAR_2022	LU / YEAR_2022	Development impacts (%)	>5% impacts
Kilcummin Diamond Downs Road	0.00	67.74	39,691	75,000	189%	Yes

Figure 24 shows development impacts during the year of opening (2022). One (1) road link has been identified where development volumes will have significant impacts (i.e. >5%) during the year of opening (2022).



Map data: Google, 2018.

Figure 24: Example #5 – Development impacts

Step 7: Calculate contribution to offset development impacts

Relevant details for each impact road segment are provided in Table 54.

Table 54: Example #5 – Road asset data provided by TMR

Segment ID	Road name	SECTION_ID	Carriageway	TDIST_START	TDIST_END	Length	Pavement type	Marginal cost
1	Kilcummin Diamond Downs Road	5309	1	0	0.1	0.10	GN	5.35
2			1	0.1	0.2	0.10	GN	109.55
3			1	0.2	0.3	0.10	GN	111.11
4			1	0.3	0.4	0.10	GN	138.96
5			1	0.4	0.5	0.10	GN	109.55
6			1	0.5	0.6	0.10	GN	109.55
7			1	0.6	0.7	0.10	GN	109.55
8			1	0.7	0.8	0.10	GN	109.55
9			1	0.8	0.9	0.10	GN	109.55
10			1	0.9	1	0.10	GN	109.55

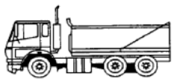
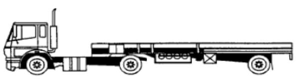
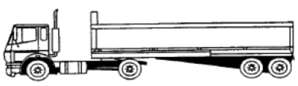
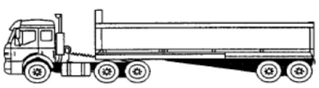
Contribution calculations for Example #5 are shown in Table 55.

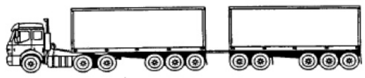
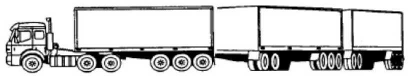
Table 55: Example #5 – Contribution calculations

Road data						Class 1 data		Class 9 data		Total	
SECTION_ID	Section	Length (km)	Pavement type	Load damage exponent	Marginal cost (CENTS/SAR-km)	Trips per year	LU/TRIP	Trips per year	LU/TRIP	LUs PER YEAR	Development contribution ($)
01	0.00-0.10	0.10	GN	4	5.35	30,000	1.0	15,000	3.0	75,000	$401.25
02	0.10-0.20	0.10	GN	4	109.55	30,000	1.0	15,000	3.0	75,000	$8,216.25
03	0.20-0.30	0.10	GN	4	111.11	30,000	1.0	15,000	3.0	75,000	$8,333.25
04	0.30-0.40	0.10	GN	4	138.96	30,000	1.0	15,000	3.0	75,000	$10,422.00
05	0.40-0.50	0.10	GN	4	109.55	30,000	1.0	15,000	3.0	75,000	$8,216.25
06	0.50-0.60	0.10	GN	4	109.55	30,000	1.0	15,000	3.0	75,000	$8,216.25
07	0.60-0.70	0.10	GN	4	109.55	30,000	1.0	15,000	3.0	75,000	$8,216.25
08	0.70-0.80	0.10	GN	4	109.55	30,000	1.0	15,000	3.0	75,000	$8,216.25
09	0.80-0.90	0.10	GN	4	109.55	30,000	1.0	15,000	3.0	75,000	$8,216.25
10	0.90-1.00	0.10	GN	4	109.55	30,000	1.0	15,000	3.0	75,000	$8,216.25
Total		**1.0**	-	-	-	-	-	-	-	-	**$76,670.25**

In summary, for Example #5 the development is required to contribute $76,670.25 per year of operation, to offset development impacts.

Appendix A: SAR calculations by Austroads heavy vehicle classification

Axle Group	1	2	3	4	5	6	7	TOTAL	Dominant Vehicle in Each Class
Class 3: Two Axle Truck									
Axles	Single	Single							
Tyres	Single	Dual							
Legal Loading (t)	6.0	9.0						15.0	
Base Load per ESA	5.4	8.2						13.6	
Unloaded Axle Group Load (t)	4.5	4.0						8.5	
Unloaded ESAs	0.482	0.057						0.54	
Unloaded SAR4 = ESAs	0.482	0.057						0.54	
Unloaded SAR5 = ESAs	0.402	0.028						0.43	
Unloaded SAR12 = ESAs	0.112	0.000						0.11	
Loaded Axle Group Load (t)	6.0	9.0						15.0	
Loaded ESAs	1.524	1.451						2.98	
Loaded SAR4 = ESAs	1.524	1.451						2.98	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	1.593						3.29	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	3.056						6.60	
Payload (t)	1.5	5.0						6.5	
Class 4: Three Axle Truck									
Axles	Single	Tandem							
Tyres	Single	Dual							
Legal Loading (t)	6.0	16.5						22.5	
Base Load per ESA	5.4	13.8						19.2	
Unloaded Axle Group Load (t)	4.5	5.0						9.5	
Unloaded ESAs	0.482	0.017						0.499	
Unloaded SAR4 = ESAs	0.482	0.017						0.499	
Unloaded SAR5 = ESAs	0.402	0.006						0.408	
Unloaded SAR12 = ESAs	0.112	0.000						0.112	
Loaded Axle Group Load (t)	6.0	16.5						22.5	
Loaded ESAs	1.524	2.044						3.568	
Loaded SAR4 = ESAs	1.524	2.044						3.568	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	2.444						4.137	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	8.536						12.077	
Payload (t)	1.5	11.5						13.0	
Class 5: Four Axle Truck									
Axles	Tandem	Tandem							
Tyres	Single	Dual							
Legal Loading (t)	11.0	16.5						27.5	
Base Load per ESA	9.2	13.8						23.0	
Unloaded Axle Group Load (t)	7.5	5.0						12.5	
Unloaded ESAs	0.442	0.017						0.459	
Unloaded SAR4 = ESAs	0.442	0.017						0.459	
Unloaded SAR5 = ESAs	0.360	0.006						0.366	
Unloaded SAR12 = ESAs	0.086	0.000						0.086	
Loaded Axle Group Load (t)	11.0	16.5						27.5	
Loaded ESAs	2.044	2.044						4.087	
Loaded SAR4 = ESAs	2.044	2.044						4.087	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	2.444	2.444						4.887	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	8.536	8.536						17.072	
Payload (t)	3.5	11.5						15.0	
Class 6: Three Axle Articulated									
Axles	Single	Single	Single						
Tyres	Single	Dual	Dual						
Legal Loading (t)	6.0	9.0	9.0					24.0	
Base Load per ESA	5.4	8.2	8.2					21.8	
Unloaded Axle Group Load (t)	4.5	4.0	4.0					12.5	
Unloaded ESAs	0.482	0.057	0.057					0.595	
Unloaded SAR4 = ESAs	0.482	0.057	0.057					0.595	
Unloaded SAR5 = ESAs	0.402	0.028	0.028					0.457	
Unloaded SAR12 = ESAs	0.112	0.000	0.000					0.113	
Loaded Axle Group Load (t)	6.0	9.0	9.0					24.0	
Loaded ESAs	1.524	1.451	1.451					4.426	
Loaded SAR4 = ESAs	1.524	1.451	1.451					4.426	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	1.593	1.593					4.879	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	3.056	3.056					9.653	
Payload (t)	1.5	5.0	5.0					11.5	
Class 7: Four Axle Articulated									
Axles	Single	Single	Tandem						
Tyres	Single	Dual	Dual						
Legal Loading (t)	6.0	9.0	16.5					31.5	
Base Load per ESA	5.4	8.2	13.8					27.4	
Unloaded Axle Group Load (t)	4.5	4.0	5.0					13.5	
Unloaded ESAs	0.482	0.057	0.017					0.556	
Unloaded SAR4 = ESAs	0.482	0.057	0.017					0.556	
Unloaded SAR5 = ESAs	0.402	0.028	0.006					0.436	
Unloaded SAR12 = ESAs	0.112	0.000	0.000					0.112	
Loaded Axle Group Load (t)	6.0	9.0	16.5					31.5	
Loaded ESAs	1.524	1.451	2.044					5.019	
Loaded SAR4 = ESAs	1.524	1.451	2.044					5.019	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	1.593	2.444					5.730	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	3.056	8.536					15.133	
Payload (t)	1.5	5.0	11.5					18.0	
Class 8: Five Axle Articulated									
Axles	Single	Tandem	Tandem						
Tyres	Single	Dual	Dual						
Legal Loading (t)	6.0	16.5	16.5					39.0	
Base Load per ESA	5.4	13.8	13.8					33.0	
Unloaded Axle Group Load (t)	4.5	5.0	5.0					14.5	
Unloaded ESAs	0.482	0.017	0.017					0.517	
Unloaded SAR4 = ESAs	0.482	0.017	0.017					0.517	
Unloaded SAR5 = ESAs	0.402	0.006	0.006					0.414	
Unloaded SAR12 = ESAs	0.112	0.000	0.000					0.112	
Loaded Axle Group Load (t)	6.0	16.5	16.5					39.0	
Loaded ESAs	1.524	2.044	2.044					5.612	
Loaded SAR4 = ESAs	1.524	2.044	2.044					5.612	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	2.444	2.444					6.581	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	8.536	8.536					20.613	
Payload (t)	1.5	11.5	11.5					24.5	

Axle Group	1	2	3	4	5	6	7	TOTAL	Dominant Vehicle in Each Class
Class 9: Six Axle Articulated (Semi Trailer)									
Axles	Single	Tandem	Tri						
Tyres	Single	Dual	Dual						
Legal Loading (t)	6.0	16.5	20.0					42.5	
Base Load per ESA	5.4	13.8	18.5					37.7	
Unloaded Axle Group Load (t)	4.5	5.0	6.5					16.0	
Unloaded ESAs	0.482	0.017	0.015					0.515	
Unloaded SAR4 = ESAs	0.482	0.017	0.015					0.515	
Unloaded SAR5 = ESAs	0.402	0.006	0.005					0.413	
Unloaded SAR12 = ESAs	0.112	0.000	0.000					0.112	
Loaded Axle Group Load (t)	6.0	16.5	20.0					42.5	
Loaded ESAs	1.524	2.044	1.366					4.934	
Loaded SAR4 = ESAs	1.524	2.044	1.366					4.934	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	2.444	1.477					5.614	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	8.536	2.549					14.625	
Payload (t)	1.5	11.5	13.5					26.5	
Class 10: B Double (Truck & Dog)									
Axles	Single	Tandem	Tri	Tri					
Tyres	Single	Dual	Dual	Dual					
Legal Loading (t)	6.0	16.5	20.0	20.0				62.5	
Base Load per ESA	5.4	13.8	18.5	18.5				56.2	
Unloaded Axle Group Load (t)	4.5	5.0	6.5	6.5				22.5	
Unloaded ESAs	0.482	0.017	0.015	0.015				0.530	
Unloaded SAR4 = ESAs	0.482	0.017	0.015	0.015				0.530	
Unloaded SAR5 = ESAs	0.402	0.006	0.005	0.005				0.419	
Unloaded SAR12 = ESAs	0.112	0.000	0.000	0.000				0.112	
Loaded Axle Group Load (t)	6.0	16.5	20.0	20.0				62.5	
Loaded ESAs	1.524	2.044	1.366	1.366				6.300	
Loaded SAR4 = ESAs	1.524	2.044	1.366	1.366				6.300	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	2.444	1.477	1.477				7.090	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	8.536	2.549	2.549				17.174	
Payload (t)	1.5	11.5	13.5	13.5				40.0	
Class 11: Double Road Train									
Axles	Single	Tandem	Tri	Tandem	Tri				
Tyres	Single	Dual	Dual	Dual	Dual				
Legal Loading (t)	6.0	16.5	20.0	16.5	20.0			79.0	
Base Load per ESA	5.4	13.8	18.5	13.8	18.5			70.0	
Unloaded Axle Group Load (t)	4.5	5.0	6.5	5.0	6.5			27.5	
Unloaded ESAs	0.482	0.017	0.015	0.017	0.015			0.547	
Unloaded SAR4 = ESAs	0.482	0.017	0.015	0.017	0.015			0.547	
Unloaded SAR5 = ESAs	0.402	0.006	0.005	0.006	0.005			0.425	
Unloaded SAR12 = ESAs	0.112	0.000	0.000	0.000	0.000			0.112	
Loaded Axle Group Load (t)	6.0	16.5	20.0	16.5	20.0			79.0	
Loaded ESAs	1.524	2.044	1.366	2.044	1.366			8.343	
Loaded SAR4 = ESAs	1.524	2.044	1.366	2.044	1.366			8.343	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	2.444	1.477	2.444	1.477			9.534	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	8.536	2.549	8.536	2.549			25.710	
Payload (t)	1.5	11.5	13.5	11.5	13.5			51.5	
Class 12: Triple Road Train									
Axles	Single	Tandem	Tri	Tandem	Tri	Tandem	Tri		
Tyres	Single	Dual	Dual	Dual	Dual	Dual	Dual		
Legal Loading (t)	6.0	16.5	20.0	16.5	20.0	16.5	20.0	115.5	
Base Load per ESA	5.4	13.8	18.5	13.8	18.5	13.8	18.5	102.3	
Unloaded Axle Group Load (t)	4.5	5.0	6.5	5.0	6.5	5.0	6.5	39.0	
Unloaded ESAs	0.482	0.017	0.015	0.017	0.015	0.017	0.015	0.580	
Unloaded SAR4 = ESAs	0.482	0.017	0.015	0.017	0.015	0.017	0.015	0.580	
Unloaded SAR5 = ESAs	0.402	0.006	0.005	0.006	0.005	0.006	0.005	0.437	
Unloaded SAR12 = ESAs	0.112	0.000	0.000	0.000	0.000	0.000	0.000	0.112	
Loaded Axle Group Load (t)	6.0	16.5	20.0	16.5	20.0	16.5	20.0	115.5	
Loaded ESAs	1.524	2.044	1.366	2.044	1.366	2.044	1.366	11.753	
Loaded SAR4 = ESAs	1.524	2.044	1.366	2.044	1.366	2.044	1.366	11.753	
Loaded SAR5 = (Legal Loading / Base Load per ESA)^5	1.694	2.444	1.477	2.444	1.477	2.444	1.477	13.454	
Loaded SAR12 = (Legal Loading / Base Load per ESA)^12	3.541	8.536	2.549	8.536	2.549	8.536	2.549	36.795	
Payload (t)	1.5	11.5	13.5	11.5	13.5	11.5	13.5	76.5	

Appendix B: Road asset data request form

Department of Transport and Main Roads

Road Asset Data Request Form

To obtain road asset data from the Department of Transport and Main Roads (TMR) please email the completed request form to RoadAssetData@tmr.qld.gov.au.

You will receive an acknowledgement notice when your request has been received and TMR will endeavour to supply requested data within 10 business days from the date of the acknowledgement notice.

Section 1: Contact information	
Name	name
Company name	company name
Address	address line address line State postcode
Contact number	phone number
Email address	email

Section 2: Data request and use
Description of data required (Data description, geographic extent and currency) Click here to enter text.
Reason data is required (Project name, why is the data required and what will it be used for) Click here to enter text.
Data users (Insert names of all persons who will be using the data and its derivatives) Click here to enter text.
Data publication and audience (How will data derivatives be published and who will be the audience) Click here to enter text.
Data licence expiry date (When will access to this data be completed) Click here to enter text.

Section 3: Data supply timing and format	
Data request date	Click here to enter a date.
Data supply required by date	Click here to enter a date.
Data supply format required	Click here to enter text.

Queensland Government